CLAIMS

1. A method of conveying a material under an electron beam, the method comprising:

exposing a biomass material to an electron beam while conveying the biomass material on a vibratory conveyor, wherein the vibratory conveyor comprises a vibratory conveyor trough having a first surface conveying the biomass, and

cooling a second surface of the vibratory conveyor trough,

wherein the first and second surfaces of the vibratory conveyor trough are in thermal communication.

2. The method of claim 1, wherein the total electron beam power has at least 50 kW of power.

3. The method of claim 1, wherein the vibratory conveyor is oscillated in a direction parallel to the direction of conveying and perpendicular to the scan horn of the electron beam.

4. The method of claim 1, wherein the vibratory conveyor comprises a metal, alloys of metals or coated metals and alloys of metals.

5. The method of claim 1, wherein the distance between the first and second surface of the vibratory conveyor trough is between about 1/64 and 2 inches.

6. The method of claim 1, further comprising cooling the second surface by contacting the second surface with a cooling enclosure containing a cooling fluid.

7. The method of claim 6, wherein the second surface of the vibratory conveyor trough forms a part of the cooling enclosure.

8. The method of claim 6, further comprising flowing fluid through the cooling enclosure by flowing the cooling fluid into the cooling enclosure through an inlet to the enclosure and flowing the fluid out of the cooling enclosure through an outlet from the cooling enclosure.

9. The method of claim 8, wherein the cooling enclosure comprises channels configured to allow the flow of the cooling agent from the inlet to the outlet.

10. The method of claim 8, further comprising maintaining a difference in the temperature of the cooling agent at the inlet of the cooling enclosure to the temperature at the outlet of the enclosure of between about 2 to 120 ° C.

11. The method of claim 7, further comprising maintaining a flow rate of cooling fluid through the cooling enclosure of between 0.5 and 150 gallons/minute.

12. An apparatus for irradiating a material, the apparatus comprising:

an electron beam irradiation device and a vibratory conveying system; wherein the vibratory conveying system comprises a cooled vibratory conveyor trough configured to convey a biomass material under the electron beam irradiation device, and

wherein the vibratory conveyor trough comprises a first surface configured to support and convey a biomass material, and a second surface that is in thermal communication with the first surface and is configured to contact a cooling system.

13. The apparatus of claim 12, wherein the cooling system comprises a cooling enclosure configured to contain a cooling fluid and positioned in thermal communication with the second surface, the cooling enclosure comprising an inlet for the cooling fluid and an outlet for the cooling fluid.

14. The apparatus of claim 13, wherein the cooling enclosure further comprises channels configured to allow flow of the cooling fluid through the enclosure from the inlet to the outlet.

15. The apparatus of claim 12, wherein the electron irradiation device can supply a power of at least 50 kW.

16. The apparatus of claim 12, wherein the vibratory conveyor trough comprises metal, alloys of metals or coated metals and alloys of metals.

17. The apparatus of claim 12, wherein the distance between the first and second surface of the vibratory conveyor trough is between about 1/64 and 2 inches.

18. A method of conveying a material, the method comprising:

conveying a biomass material through a field of accelerated electrons, the electrons impinging upon a treatment zone of a vibratory conveyor, wherein the treatment zone includes a beam dump in thermal communication with the treatment zone.

19. The method of claim 18, wherein the beam dump is positioned on a side of the vibratory conveyor opposite impinging electrons.

20. The method of claim 18, wherein the beam dump is integral with the treatment zone.

21. The method of claim 18, further comprising removing heat from the beam dump at a rate of between about 10 kW to 700 kW.

22. The method of claim 21, further comprising removing the heat from the beam dump by flowing a cooling fluid through channels disposed within the beam dump.

23. The method of claim 22, wherein fluid enters the channels disposed in the beam dump through an inlet and exits the channels through an outlet at a temperature less than about 140 ° C.

24. A method of conveying a material, the method comprising:

conveying a biomass material through a field of accelerated electrons, the electrons impinging upon the treatment zone of a vibratory conveyor, wherein the treatment zone includes both a beam dump in thermal communication with the treatment zone and a cooling enclosure in thermal communication with the treatment zone.

25. The method of claim 24, wherein the conveyor comprises a conveyor trough conveying the biomass.

26. The method of claim 25, wherein the conveyor trough comprises a first surface of the conveyor trough conveying the biomass, and the method further comprises cooling a second surface of the conveyor trough, wherein the first and second surfaces of the conveyor trough are in thermal communication.

27. The method of claim 25, wherein the conveyor trough comprises a metal, alloys of metals or coated metals and alloys of metals.

28. The method of claim 26, wherein the distance between the first and second surface of the conveyor trough is between about 1/64 and 2 inches.

29. The method of claim 26, further comprising cooling the second surface by contacting the second surface with a cooling enclosure containing a cooling fluid.

30. The method of claim 29, wherein the second surface of the conveyor trough forms a part of the cooling enclosure.

31. The method of claim 29, further comprising flowing fluid through the cooling enclosure by flowing the cooling fluid into the cooling enclosure through an inlet to the enclosure and flowing the fluid out of the cooling enclosure through an outlet from the cooling enclosure.

32. The method of claim 31, wherein the cooling enclosure comprises channels configured to allow the flow of the cooling agent from the inlet to the outlet.

33. The method of claim 31, further comprising maintaining a difference in the temperature of the cooling agent at the inlet of the cooling enclosure to the temperature at the outlet of the enclosure of between about 2 to 120 ° C.

34. The method of claim 32, further comprising maintaining a flow rate of cooling fluid through the cooling enclosure of between 0.5 and 150 gallons/minute.

35. An apparatus for irradiating a material, the apparatus comprising:

an electron beam irradiation device and a conveying system;

wherein the conveying system comprises a cooled conveyor trough configured to convey a biomass material under the electron beam irradiation device and

wherein the conveyor trough comprises a first surface configured to support and convey a biomass material, and a second surface that is in thermal communication with the first surface and is configured to contact a cooling system.

36. The apparatus of claim 35, wherein the cooling system comprises a cooling enclosure configured to contain a cooling fluid and positioned in thermal communication with the second surface, the cooling enclosure comprising an inlet for the cooling fluid and an outlet for the cooling fluid.

37. The apparatus of claim 36, wherein the cooling enclosure further comprises channels configured to allow flow of the cooling fluid through the enclosure from the inlet to the outlet.

38. The apparatus of claim 35, wherein the electron irradiation device can supply a power of at least 50 kW.

39. The apparatus of claim 35, wherein the conveyor trough comprises metal, alloys of metals or coated metals and alloys of metals.

40. The apparatus of claim 35, wherein the distance between the first surface and the second surface of the conveyor trough is between about 1/64 and 2 inches.

41. A method of conveying a material under an electron beam, the method comprising:

exposing a biomass material to an electron beam having a scan horn, while conveying the biomass material on a vibratory conveyor that is oscillated in a direction parallel to the direction of conveying and perpendicular to the scan horn of the electron beam.

42. The method of claim 41, wherein the electron beam can supply a power of at least 50 kW.

43. The method of claim 41, wherein the conveyor comprises a conveyor trough conveying the biomass.

44. The method of claim 43, wherein the conveyor trough comprises a first surface of the conveyor trough conveying the biomass, and the method further comprises cooling a second surface of the conveyor trough, wherein the first and second surfaces of the conveyor trough are in thermal communication.

45. The method of claim 43, wherein the conveyor trough comprises a metal, alloys of metals or coated metals and alloys of metals.

46. The method of claim 44, wherein the distance between the first and second surface of the conveyor trough is between about 1/64 and 2 inches.

47. The method of claim 44, further comprising cooling the second surface by contacting the second surface with a cooling enclosure containing a cooling fluid.

48. The method of claim 47, wherein the second surface of the conveyor trough forms a part of the cooling enclosure.

CLAIMS

1. A method of conveying a material under an electron beam, the method comprising:

exposing a biomass material to an electron beam while conveying the biomass material on a vibratory conveyor, wherein the vibratory conveyor comprises a vibratory conveyor trough having a first surface conveying the biomass, and

cooling a second surface of the vibratory conveyor trough,

wherein the first and second surfaces of the vibratory conveyor trough are in thermal communication.

2. The method of claim 1, wherein the total electron beam power has at least 50 kW of power.

3. The method of claim 1, wherein the vibratory conveyor is oscillated in a direction parallel to the direction of conveying and perpendicular to the scan horn of the electron beam.

4. The method of claim 1, wherein the vibratory conveyor comprises a metal, alloys of metals or coated metals and alloys of metals.

5. The method of claim 1, wherein the distance between the first and second surface of the vibratory conveyor trough is between about 1/64 (0.04 cm) and 2 inches (5 cm).

6. The method of claim 1, further comprising cooling the second surface by contacting the second surface with a cooling enclosure containing a cooling fluid.

7. The method of claim 6, wherein the second surface of the vibratory conveyor trough forms a part of the cooling enclosure.

8. The method of claim 6, further comprising flowing fluid through the cooling enclosure by flowing the cooling fluid into the cooling enclosure through an inlet to the enclosure and flowing the fluid out of the cooling enclosure through an outlet from the cooling enclosure.

9. The method of claim 8, wherein the cooling enclosure comprises channels configured to allow the flow of the cooling agent from the inlet to the outlet.

10. The method of claim 8, further comprising maintaining a difference in the temperature

of the cooling agent at the inlet of the cooling enclosure to the temperature at the outlet of the enclosure of between about 2 to 120 ° C.

11. The method of claim 7, further comprising maintaining a flow rate of cooling fluid through the cooling enclosure of between 0.5 (1.89 liters/minute) and 150 gallons/minute (568 liters/minute).

12. A method of conveying a material, the method comprising:

conveying a biomass material through a field of accelerated electrons, the electrons impinging upon a treatment zone of a vibratory conveyor, wherein the treatment zone includes a beam dump in thermal communication with the treatment zone.

13. The method of claim 12, wherein the beam dump is positioned on a side of the vibratory conveyor opposite impinging electrons.

14. The method of claim 12, wherein the beam dump is integral with the treatment zone.

15. The method of claim 12, further comprising removing heat from the beam dump at a rate of between about 10 kW to 700 kW.

16. The method of claim 15, further comprising removing the heat from the beam dump by flowing a cooling fluid through channels disposed within the beam dump.

17. The method of claim 16, wherein fluid enters the channels disposed in the beam dump through an inlet and exits the channels through an outlet at a temperature less than about 140 ° C.

18. A method of conveying a material, the method comprising:

conveying a biomass material through a field of accelerated electrons, the electrons impinging upon the treatment zone of a vibratory conveyor, wherein the treatment zone includes both a beam dump in thermal communication with the treatment zone and a cooling enclosure in thermal communication with the treatment zone.

19. The method of claim 18, wherein the conveyor comprises a conveyor trough conveying the biomass.

20. The method of claim 19, wherein the conveyor trough comprises a first surface of the conveyor trough conveying the biomass, and the method further comprises cooling a second surface of the conveyor trough, wherein the first and second surfaces of the conveyor trough are in thermal communication.

21. The method of claim 19, wherein the conveyor trough comprises a metal, alloys of metals or coated metals and alloys of metals.

22. The method of claim 20, wherein the distance between the first and second surface of the conveyor trough is between about 1/64 (0.04 cm) and 2 inches (5 cm).

23. The method of claim 20, further comprising cooling the second surface by contacting the second surface with a cooling enclosure containing a cooling fluid.

24. The method of claim 23, wherein the second surface of the conveyor trough forms a part of the cooling enclosure.

25. The method of claim 23, further comprising flowing fluid through the cooling enclosure by flowing the cooling fluid into the cooling enclosure through an inlet to the enclosure and flowing the fluid out of the cooling enclosure through an outlet from the cooling enclosure.

26. The method of claim 25, wherein the cooling enclosure comprises channels configured to allow the flow of the cooling agent from the inlet to the outlet.

27. The method of claim 25, further comprising maintaining a difference in the temperature of the cooling agent at the inlet of the cooling enclosure to the temperature at the outlet of the enclosure of between about 2 to 120 ° C.

28. The method of claim 26, further comprising maintaining a flow rate of cooling fluid through the cooling enclosure of between 0.5 (1.89 liters/minute) and 150 gallons/minute (568 liters/minute).

29. A method of conveying a material under an electron beam, the method comprising:

exposing a biomass material to an electron beam having a scan horn, while conveying the biomass material on a vibratory conveyor that is oscillated in a direction parallel to the direction

of conveying and perpendicular to the scan horn of the electron beam;

wherein the conveyor comprises a conveyor trough conveying the biomass; and

wherein the conveyor trough comprises a first surface of the conveyor trough conveying the biomass, and the method further comprises cooling a second surface of the conveyor trough, wherein the first and second surfaces of the conveyor trough are in thermal communication.

30. The method of claim 29, wherein the distance between the first and second surface of the conveyor trough is between about 1/64 (0.04 cm) and 2 inches (5 cm).

31. The method of claim 29, further comprising cooling the second surface by contacting the second surface with a cooling enclosure containing a cooling fluid.

32. The method of claim 31, wherein the second surface of the conveyor trough forms a part of the cooling enclosure.