Claims:

1. A method of processing particulate carbonaceous feedstock comprising:
simultaneously subjecting feedstock to a particle size reduction process and pyrolysis.

2. The method according to claim 1 wherein the size reduction process comprises either or both grinding and crushing the feedstock.

3. The method according to claim 1 or 2 wherein the size reduction process comprises repeatedly contacting the feedstock with the one or more hard objects.

4. The method according to claim 3 wherein contacting the feedstock with one or more hard objects comprises impacting with the feedstock with the one or more objects.

5. The method according to claim 4 wherein the one or more objects are provided as grinding media composes of a plurality of separate and freely movable objects and repeatedly impacting the feedstock and comprises imparting momentum to the grinding media and causing the grinding media to impact the feedstock.

6. The method according to any one of claims 3 to 5 comprising providing a vessel in which the size reduction process and the pyrolysis occur simultaneously, and feeding the feedstock to the vessel, the vessel having a volume V and an inner diameter D.

7. The method according to claim 6 comprising providing the grinding media in the vessel and rotating the vessel.

8. The method according to claim 6 or 7 comprising providing the grinding media in an amount to occupy 10% to 50% of the volume V of the vessel.

9. The method according to claim 6 or 7 comprising rotating the vessel at a speed of 55% to 90% of a critical speed CS wherein:
$CS = 42.3/D^{0.5}$rpm.

10. The method according to any one of claims 3 to 9 comprising providing the objects as objects made of one of the following: silica, pebble, or steel.

11. The method according to any one of claims 6 to 10 comprising providing a steel, silica or refractory lining on the inside of the vessel.

12. The method according to any one of claims 7 to 11 comprising providing a continuous feed of grinding media through the vessel.

13. The method according to any one of claims 3 to 10 wherein the pyrolysis comprises transferring heat from the objects to the feedstock by conduction and convection.

14. The method according to claim 13 comprising heating the objects prior to the objects coming into contact with the feedstock.

15. The method according to claim 14 comprising using waste heat from a process of heating the objects to dry the feedstock prior to coming into contact with the objects.

16. The method according to claim 13 comprising heating the objects while the objects are in contact with the feedstock.

17. The method according to any one of claims 6 to 16 wherein the pyrolysis comprises heating the vessel.

18. The method according to any one of claims 1 to 16 comprising generating heat for the pyrolysis by burning non-condensable gases and/or char produced by the pyrolysis of the feedstock.

19. The method according to any one of claims 1 to 18 comprising conducting pyrolysis at a temperature sufficient to cause torrefaction of the feedstock.

20. The method according to any one of claims 6 to 19 comprising providing limited oxygen into the vessel to enable partial combustion of the volatiles

and/or char to generate heat for the pyrolysis of the feedstock.

21. The method according to any one of claims 1 to 20 comprising condensing organic vapour generated by the pyrolysis to form oil.

22. The method according to any one of claims 1 to 20 comprising condensing organic vapour generated by the pyrolysis on char generated by the pyrolysis to produce an oil/char mixture.

23. The method according to any one of claims 1 to 20 comprising feeding products generated by the pyrolysis of the feedstock as a fuel to a combustion or gasification system.

24. The method according to claim 23 comprising using the combustion or gasification system as a source of heat for the pyrolysis.

25. The method according to any one of claims 1 to 20 comprising feeding products generated by the pyrolysis of the feedstock to a boiler or gasifier as a co-firing fuel.

26. The method according to any one of claims 1 to 18 comprising conducting pyrolysis at a temperature of between 350°C and 650°C

27. A plant for simultaneous grinding and pyrolysis of particulate carbonaceous feedstock comprising:

a machine capable of reducing particle size of the feedstock; and, a heat source capable of heating the feedstock while the machine operates to reduce the particle size of the feedstock to effect pyrolysis of the feedstock.

28. The plant according to claim 27 wherein the machine is a grinding machine or a milling machine.

29. The plant according to claim 27 or 28 wherein the machine comprises grinding media consisting of a plurality of separate and freely movable objects and a vessel in which the grinding media and the feedstock come into contact with each other to effect particle size reduction of the feedstock.

30. The plant according to claim 29 wherein the machine operates by rotating the vessel to impart momentum to the grinding media and causing the grinding media to repeatedly impact the feedstock.

31. The plant according to claim 29 or 30 comprising providing a circulating feed of grinding media through the vessel.

32. The plant according to claim to any one of claims 28 to 31 wherein the grinding media when in the vessel occupy 10% to 50% of the volume V of the vessel.

33. The plant according to claim to any one of claims 30 to 32 wherein the vessel is rotated a speed of 55% to 90% of a critical speed CS wherein: $CS = 42.3/D^{0.5}$rpm, where D is the internal diameter of the vessel in metres.

34. The plant according to claim to any one of claims 29 to 33 wherein the heat source heats the grinding media prior to the grinding media contacting the feedstock.

35. The plant according to claim to any one of claims 29 to 34 wherein the heat source heats the vessel.

36. The plant according to any one of claims 29 to 34 wherein the heat source comprises a burner and a gas feed system to feed non-condensable gas from the pyrolysis of the feedstock to the burner.

37. The plant according to any one of claims 29 to 36 comprising a condenser through which gases and vapours from the pyrolysis of the feedstock are drawn to condense and capture organic components of the pyrolysis vapours.

38. The plant according to any one of claims 29 to 37 wherein the heat source is arranged to provide a pyrolysis temperature sufficient to cause torrefaction of the biomass.

39. The plant according to any one of claims 29 to 36 wherein the plant is arranged to condense organic vapour generated by the pyrolysis on char

generated by the pyrolysis to produce an oil/char mixture.

40. The plant according to any one of claims 29 to 36 wherein the plant is part of a combustion or gasification system having a combustor or gasifier, the plant being arranged to feed products generated by the pyrolysis of the feedstock as a fuel to the combustor or gasifier.

41. The plant according to claim 40 wherein heat generated by the combustor or gasifier as a or the source of heat for the pyrolysis.

42. The plant according to any one of claims 29 to 36 wherein the plant is be arranged to feed products generated by the pyrolysis of the feedstock to a boiler or gasifier as a co-firing fuel.

43. The plant according to any one of claims 29 to 42 comprising a hopper for supplying the feedstock to the machine, the hopper being provided with an agitation mechanism capable of a combined rotational motion about an axis and linear reciprocation motion along the axis to facilitate a flow of the feedstock from the hopper to the machine.

44. The plant according to any one of claims 29 to 37 wherein the heat source is arranged to provide a pyrolysis temperature of between 350°C and 650°C.

Claims:

1. A method of processing particulate carbonaceous feedstock comprising biomass and/or coal, the method comprising:

feeding the feedstock to a vessel having an inner diameter D meters;

rotating the vessel at a speed of 55% to 90% of a critical speed CS wherein: $CS = 42.3/D^{0.5}$ rpm;

while the vessel is rotating at the speed of 55% to 90% of CS simultaneously subjecting the feedstock fed to the vessel to a particle size reduction process and pyrolysis to produce at least a gas being condensable to form a liquid oil and solid char particles.

2. The method according to claim 1 wherein the size reduction process comprises either or both: grinding; and crushing, the feedstock.

3. The method according to claim 1 or 2 wherein the size reduction process comprises repeatedly contacting the feedstock with the one or more hard objects, the hard objects being of sufficient hardness to break off a char layer formed on the particles by the pyrolysis.

4. The method according to claim 3 wherein contacting the feedstock with one or more hard objects comprises impacting the feedstock with the one or more hard objects.

5. The method according to claim 4 wherein the one or more hard objects are provided as a plurality of separate and freely movable objects; and wherein impacting the feedstock comprises imparting momentum to the freely movable objects by action of the rotating vessel lifting the free movable objects and allowing the lifted freely movable objects to fall to impact the feedstock.

6. The method according to claim 5 wherein the vessel has a volume V and the freely movable objects are provided in an amount to occupy 10% to 50% of the volume V.

7. The method according to 5 or 6 comprising providing the freely movable objects as objects made of one or more of the following: silica, pebble, or steel.

8. The method according to any one of claims 5 to 7 comprising providing a continuous feed of the freely movable objects through the vessel.

9. The method according to any one of claims 5 to 8 wherein the pyrolysis comprises transferring heat from the freely movable objects to the feedstock by conduction and convection.

10. The method according to claim 9 comprising heating the freely movable objects prior to the objects coming into contact with the feedstock.

11. The method according to claim 10 comprising using waste heat from a process of heating the freely movable objects to dry the feedstock prior to coming into contact with the objects.

12. The method according to claim 9 comprising heating the freely movable objects while they are in contact with the feedstock.

13. The method according to any one of claims 1 to12 wherein the pyrolysis comprises heating the vessel.

14. The method according to any one of claims 1 to 13 comprising generating heat for the pyrolysis by burning non-condensable gases and/or char produced by the pyrolysis of the feedstock.

15. The method according to any one of claims 1 to 14 comprising conducting pyrolysis at a temperature sufficient to cause torrefaction of the feedstock.

16. The method according to any one of claims 1 to 15 comprising providing limited oxygen into the vessel to enable partial combustion of the volatiles and/or char to generate heat for the pyrolysis of the feedstock.

17. The method according to any one of claims 1 to 16 comprising condensing organic vapour generated by the pyrolysis to form the oil.

18. The method according to any one of claims 1 to 16 comprising condensing organic vapour generated by the pyrolysis on char generated by

the pyrolysis to produce an oil/char mixture.

19. The method according to any one of claims 1 to 16 comprising feeding products generated by the pyrolysis of the feedstock as a fuel to a combustion or gasification system.

20. The method according to claim 19 comprising using the combustion or gasification system as a source of heat for the pyrolysis.

21. The method according to any one of claims 1 to 16 comprising feeding products generated by the pyrolysis of the feedstock to a boiler or gasifier as a co-firing fuel.

22. The method according to any one of claims 1 to 21 comprising conducting pyrolysis at a temperature of between 350°C and 650°C.

23. The method according to any one of claims 1 to 22 comprising providing a steel, silica or refractory lining on an inside of the vessel.

24. A plant for simultaneous grinding and pyrolysis of particulate carbonaceous feedstock comprising biomass and/or coal, the plant comprising:

a machine capable of reducing particle size of the feedstock, wherein the machine comprises a vessel rotating at a speed of 55% to 90% of a critical speed CS wherein: $CS = 42.3/D^{0.5}$ rpm, where D is the internal diameter of the vessel in meters; and, a heat source capable of heating the feedstock while in the rotating vessel, wherein the plant is operable to reduce the particle size of the feedstock and to effect pyrolysis of the feedstock to produce at least a gas being condensable to form a liquid oil and solid char particles that are capable of being combusted.

25. The plant according to claim 24 wherein the machine is a grinding machine or a milling machine.

26. The plant according to claim 24 comprising a plurality of separate and freely movable hard objects disposed in the vessel, the hard objects being of sufficient hardness to break off a char layer formed on the particles by the pyrolysis to thereby effect particle size reduction of the feedstock.

27. The plant according to claim 26 wherein the machine operates by rotating the vessel to impart momentum to the freely movable hard objects by lifting the freely movable hard objects and allowing the objects to fall to impact with the feedstock.

28. The plant according to claim 26 or 27 comprising providing a circulating feed of freely movable hard objects through the vessel.

29. The plant according to any one of claims 24 to 28 wherein the vessel has a volume V and the freely movable hard objects when in the vessel occupy 10% to 50% of the volume V.

30. The plant according o any one of claims 26 to 29 wherein the heat source heats the freely movable hard objects prior to the freely movable hard objects contacting the feedstock.

31. The plant according to any one of claims 24 to 30 wherein the heat source heats the vessel.

32. The plant according to any one of claims 24 to 31 wherein the heat source comprises a burner and a gas feed system to feed non-condensable gas from the pyrolysis of the feedstock to the burner.

33. The plant according to any one of claims 24 to 32 comprising a condenser through which gases and vapours from the pyrolysis of the feedstock are drawn to condense and capture organic components of the pyrolysis vapours.

34. The plant according to any one of claims 24 to 33 wherein the heat source is arranged to provide a pyrolysis temperature sufficient to cause torrefaction of the feedstock.

35. The plant according to any one of claims 24 to 32 wherein the plant is arranged to condense organic vapour generated by the pyrolysis on char generated by the pyrolysis to produce an oil/char mixture.

36. The plant according to any one of claims 24 to 32 wherein the plant is part of a combustion or gasification system having a combustor or gasifier, the plant being arranged to feed products generated by the pyrolysis of the feedstock as a fuel to the combustor or gasifier.

37. The plant according to claim 36 wherein heat generated by the combustor or gasifier is a or the source of heat for the pyrolysis.

38. The plant according to any one of claims 24 to 32 wherein the plant is be arranged to feed products generated by the pyrolysis of the feedstock to a boiler or gasifier as a co-firing fuel.

39. The plant according to any one of claims 24 to 38 comprising a hopper for supplying the feedstock to the machine, the hopper being provided with an agitation mechanism capable of a combined rotational motion about an axis and linear reciprocation motion along the axis to facilitate a flow of the feedstock from the hopper to the machine.

40. The plant according to any one of claims 24 to 39 wherein the heat source is arranged to provide a pyrolysis temperature of between 350°C and 650°C.