CLAIMS:

1. A method of gasifying a carbonaceous material, the method comprising the steps of:

pyrolysing the carbonaceous material to produce volatiles and char;

separating the char and the volatiles;

gasifying the char;

reforming the volatiles to produce a product gas; and

passing partially reformed volatiles and/or product gas through a product gas cleaning zone.

2. The method of claim 1, wherein the product gas cleaning zone comprises a catalyst bed.

3. The method of claim 2, wherein the catalyst bed comprises a moving bed of solid catalyst.

4. The method of any one of the preceding claims, wherein the product gas cleaning zone comprises a plurality of catalyst beds arranged in series.

5. The method of any one of claims 2 to 4, wherein the catalyst bed comprises char, a char-supported catalyst or ilmenite.

6. The method of claim 5, wherein, when the catalyst bed comprises char or a char-supported catalyst, the char or char-supported catalyst is prepared from the pyrolysis and/or partial gasification of the carbonaceous material.

7. The methods of claim 5 or claim 6, wherein the method further comprises discharging spent char or char-supported catalyst from the catalyst bed and gasifying the spent char or char-supported catalyst.

8. The method of any one of the preceding claims, wherein the step of pyrolysing the carbonaceous material comprises pyrolysing the carbonaceous material for a period of sufficient length to convert substantially all the carbonaceous material to volatiles and char.

9. The method of any one of the preceding claims, wherein the step of pyrolysing the carbonaceous material comprises heating the carbonaceous material with a counter-current stream of hot gas, which also achieves the partial gasification of the feedstock.

10. The method of claim 9, wherein the hot gas is produced in the char gasification zone.

11. The method of claim 9, wherein the hot gas is produced from combusting product gas in the char gasification zone or the reforming zone.

12. The method of any one of the preceding claims, wherein the step of gasifying the char comprises reacting the char with a controlled amount of an oxygen-containing gas.

13. A method of treating raw product gas produced from gasification of low-rank carbonaceous materials, wherein the raw product gas contains partially reformed volatiles, tar residues and contaminants, the method comprising passing the raw product gas through a catalyst bed.

14. The method of claim 13, wherein the method of treating the raw product gas comprises passing the raw product gas through a catalyst bed that comprises a moving bed of char or char-supported catalyst.

15. A gasification system for gasifying a carbonaceous material, the gasification system comprising:

a reforming zone for reforming volatiles to produce a product gas;

a char gasification zone for gasifying char;

a pyrolysis zone for pyrolysing carbonaceous material, the pyrolysis zone being in fluid communication with the reforming zone and the char gasification zone in an arrangement whereby volatiles and char formed in the pyrolysis zone are separated and directed to the reforming zone and the char gasification zone, respectively; and

a product gas cleaning zone in fluid communication with the reforming zone in an arrangement whereby partially reformed volatiles and/or product gas are passed through the product gas cleaning zone.

16. The system of claim 15, wherein the pyrolysis zone is disposed intermediate to the reforming zone and the char gasification zone.

17. The system of claim 15 or claim 16, wherein the product gas cleaning zone comprises a catalyst bed.

18. The system of any one of claims 15 to 17, wherein the gasification system comprises a gasification vessel having defined therein the reforming, char gasification and pyrolysis zones.

19. The system of claim 18, wherein the char gasification zone is disposed in a lower portion of the gasification vessel.

20. The system of claim 18 or claim 19, wherein the reforming zone is disposed in an upper portion of the gasification vessel.

21. The system of any one of claims 15 to 20, wherein the pyrolysis zone is configured to retain the carbonaceous material in the pyrolysis zone for a residence time of sufficient length to convert substantially all the carbonaceous material to volatiles and char.

22. The system of any one of claims 15 to 21, wherein a portion of the char formed in the pyrolysis zone is separated from the remaining carbonaceous material as a gas cleaning catalyst and directed to the product gas cleaning zone.

23. The system of any one of claims 15 to 22, wherein the gasification system comprises a separate vessel for pyrolysing and/or partially gasifying a carbonaceous material so as to prepare char or char-supported catalysts, the system being arranged so as to allow the pyrolysed and/or partially gasified carbonaceous material to be discharged into the product gas cleaning zone to act as the catalysts for cleaning of the product gas.

24. The system of claim 23, wherein the product gas cleaning zone coincides with the char gasification zone.

25. The system of claim 24, wherein the char gasification zone is configured and operated under conditions whereby char undergoes partial or complete gasification.

26. The system of any one of claims 15 to 25, wherein the gasification system is provided with a char storage zone disposed intermediate to the pyrolysis zone and the product gas cleaning zone, and a control system associated therewith, the control system being arranged, in use, to control a flow rate of char to the product gas cleaning zone.

27. An apparatus for pyrolysing and partially gasifying carbonaceous materials, the apparatus comprising:

at least one element having a surface arranged such that, when the apparatus receives carbonaceous material, the received carbonaceous material is in contact with the surface for a time period of sufficient length so as to pyrolyse the carbonaceous material;

wherein the apparatus is arranged such that the surface receives heat for pyrolysing and partially gasifying the carbonaceous material.

28. The apparatus of claim 27, wherein the surface has a downwardly sloping portion arranged so as to assist in contacting the carbonaceous material with the surface for the time period.

29. The apparatus of claim 27 or claim 28, comprising a plurality of surfaces in a cascade arrangement and wherein the pyrolyser is arranged such that carbonaceous material is transferred to successive surfaces of the cascade arrangement after a period of time of sufficient length so as to pyrolyse and partially gasify the carbonaceous material.

30. The apparatus of any one of claims 27 to 29, wherein the apparatus comprises an agitator associated with the at least one element, the agitator being arranged so as to agitate carbonaceous material in contact with the surface so as to transfer the carbonaceous material to a region below the surface.

31. The apparatus of claim 30, wherein the plurality of surfaces are arranged in a vertical cascade arrangement and the apparatus comprises a rotatable shaft extending vertically

through the plurality of surfaces wherein agitators associated with respective surfaces are operable by rotation of the rotatable shaft.

CLAIMS:

1. A method of gasifying a carbonaceous material, the method comprising the steps of:

pyrolysing the carbonaceous material to produce volatiles and char;

separating the char and the volatiles; and, following the steps of pyrolysing the carbonaceous material and separating the char and the volatiles;

gasifying the char;

reforming the volatiles to produce a product gas; and

passing partially reformed volatiles and/or product gas through a product gas cleaning zone;

wherein at least the steps of pyrolysing the carbonaceous material, gasifying the char, and reforming the volatiles to produce a product gas are performed in a vessel that has a pyrolysis zone, a char gasification zone, and a reforming zone, and that is directly coupled with the product gas cleaning zone.

2. The method of claim 1, wherein the step of pyrolysing the carbonaceous material is performed within the temperature range of 900°C to 1200°C and the step of reforming the volatiles is performed within the temperature range of 700°C to 1000°C.

3. The method of claim 1 or claim 2, wherein the step of pyrolysing the carbonaceous material is performed using a pyrolyser.

4. The method of any one of claims 1 to 3, wherein the product gas cleaning zone comprises a catalyst bed.

5. The method of claim 4, wherein the catalyst bed comprises a moving bed of solid catalyst.

6. The method of any one of the preceding claims, wherein the product gas cleaning zone comprises a plurality of catalyst beds arranged in series.

7. The method of any one of claims 4 to 6, wherein the catalyst bed comprises char, a char-supported catalyst or ilmenite.

8. The method of claim 7, wherein, when the catalyst bed comprises char or a char-supported catalyst, the char or char-supported catalyst is prepared from the pyrolysis and/or partial gasification of the carbonaceous material.

9. The methods of claim 7 or claim 8, wherein the method further comprises discharging spent char or char-supported catalyst from the catalyst bed and gasifying the spent char or char-supported catalyst.

10. The method of any one of the preceding claims, wherein the step of pyrolysing the carbonaceous material comprises pyrolysing the carbonaceous material for a period of sufficient length to convert substantially all the carbonaceous material to volatiles and char.

11. The method of any one of the preceding claims, wherein the step of pyrolysing the carbonaceous material comprises heating the carbonaceous material with a counter-current stream of hot gas.

12. The method of claim 11, wherein the hot gas is produced in the char gasification zone.

13. The method of claim 11, wherein the hot gas is produced from combusting product gas in the char gasification zone or the reforming zone.

14. The method of any one of the preceding claims, wherein the step of gasifying the char comprises reacting the char with a controlled amount of an oxygen-containing gas.

15. A gasification system for gasifying a carbonaceous material, the gasification system comprising:

a vessel comprising a reforming zone, a char gasification zone and a pyrolysis zone, the vessel being arranged such that the reforming zone, the char gasification zone and the pyrolysis zone are substantially separate from another;

the reforming zone being arranged to reform volatiles to produce a product gas;

the char gasification zone being arranged to gasify char; and

the pyrolysis zone to pyrolyse carbonaceous material to produce volatiles and char, and disposed intermediate to and in fluid communication with the reforming zone and the char gasification zone;

wherein the vessel is arranged such that following pyrolysis of the carbonaceous material and separating the char and the volaties, the volities and the char are directed to the reforming zone and the char gasification zone, respectively; and

wherein the gasification system further comprises a product gas cleaning zone that is directly coupled with the vessel and in fluid communication with the reforming zone in an arrangement whereby partially reformed volatiles and/or product gas are passed through the product gas cleaning zone.

16. The system of claim 15, wherein the pyrolysis zone is arranged so as to pyrolyse the carbonaceous material within the temperature range of 900°C to 1200°C and the reforming zone is arranged so as to reform the volatiles within the temperature range of 700°C to 1000°C.

17. The system of claim 15 or claim 16, wherein the pyrolysis zone comprises a pyrolyser arranged to pyrolyse the carbonaceous material.

18. The system of any one of claims 15 to 17, wherein the product gas cleaning zone comprises a catalyst bed.

19. The system of any one of claims 15 to 18, wherein the char gasification zone is disposed in a lower portion of the gasification vessel.

20. The system of any one of claims 15 to 19, wherein the reforming zone is disposed in an upper portion of the gasification vessel.

21. The system of any one of claims 15 to 20, wherein the pyrolysis zone is configured to retain the carbonaceous material in the pyrolysis zone for a residence time of sufficient length to convert substantially all the carbonaceous material to volatiles and char.

22. The system of any one of claims 15 to 21, wherein a portion of the char formed in the pyrolysis zone is separated from the remaining carbonaceous material as a gas cleaning catalyst and directed to the product gas cleaning zone.

23. The system of any one of claims 15 to 22, wherein the gasification system is provided with a char storage zone disposed intermediate to the pyrolysis zone and the product gas cleaning zone, and a control system associated therewith, the control system being arranged, in use, to control a flow rate of char to the product gas cleaning zone.

24. The system of any one of claims 15 to 23, wherein the gasification system comprises an apparatus for pyrolysing and partially gasifying carbonaceous materials, the apparatus comprising:

at least one element having a surface arranged such that, when the apparatus receives carbonaceous material, the received carbonaceous material is in contact with the surface for a time period of sufficient length so as to pyrolyse the carbonaceous material;

wherein the apparatus is arranged such that the surface receives heat for pyrolysing and partially gasifying the carbonaceous material.

25. The apparatus of claim 24, wherein the surface has a downwardly sloping portion arranged so as to assist in contacting the carbonaceous material with the surface for the time period.

26. The system of claim 24 or claim 25, comprising a plurality of elements, each having a respective surface and being arranged such that the surfaces are in a cascade arrangement and wherein the pyrolyser is arranged such that carbonaceous material is transferred to successive surfaces of the cascade arrangement after a period of time of sufficient length so as to pyrolyse and partially gasify the carbonaceous material.

27. The system of any one of claims 24 to 26, wherein the apparatus comprises an agitator associated with the at least one element, the agitator being arranged so as to agitate carbonaceous material in contact with the surface so as to transfer the carbonaceous material to a region below the surface.

28. The system of claim 27, comprising a plurality of elements, each having a respective surface and being arranged such that the plurality of surfaces are arranged in a vertical cascade arrangement, the apparatus further comprising a rotatable shaft extending vertically through the plurality of elements wherein agitators associated with respective surfaces are operable by rotation of the rotatable shaft.

29. A gasification system for gasifying a carbonaceous material, the gasification system being arranged to operate in accordance with the method as defined in any one of claims 1 to 14.