CLAIMS

What is claimed is:

1. An apparatus for pyrolyzing hydrocarbonaceous materials to produce useful vapor products and solid products comprising:

a generally cylindrical, linear reactor having a screw means for transporting said hydrocarbonaceous materials through said reactor,

means for feeding hydrocarbonaceous materials to said reactor,

means for heating said hydrocarbonaceous materials whereby they are processed and pyrolyzed to produce vapor products and solid products,

wherein said screw means extends substantially the length of said linear reactor;

wherein said screw means has zones for advancing and mixing hydrocarbonaceous material in the reactor,

means for removing vapor products from said processed hydrocarbonaceous materials in said reactor,

means for removing solid products from said reactor,

wherein said reactor has zones that are maintained in the apparatus within defined ranges of temperature,

means whereby said hydrocarbonaceous material is maintained within a zone for a range of defined residence times,

wherein said zones collectively comprise the complete environments required for pyrolysis,

means for rotating said screw,

wherein said screw means has a plurality of flight configurations for compressing said hydrocarbonaceous materials, for melting said hydrocarbonaceous materials to convert said hydrocarbonaceous materials from a solid to a liquid state, for mixing, destabilizing, desulfurizing, and dehalogenating said hydrocarbonaceous materials, for pyrolyzing said hydrocarbonaceous materials, for devolatilizing the pyrolyzed hydrocarbonaceous materials, and for discharging solid products from said hydrocarbonaceous materials.

2. The apparatus of claim **1** wherein the means for removing moisture from said hydrocarbonaceous material includes means for compressing and heating said hydrocarbonaceous materials to remove air and moisture from said hydrocarbonaceous materials.

3. The apparatus of claim **1** wherein the flight configurations of said screw incorporates a ribbon mixer.

4. The apparatus of claim **1** wherein said reactor is oriented with respect to the horizon at an angle between about -20° to about +20°, preferably in an incline between about +2° to about +6°.

5. The apparatus of claim **1** wherein said reactor is oriented with respect to the horizon at an angle between about -20° to about +20°, preferably in a decline between about -2° to about -6°.

6. The apparatus of claim **1** further comprising a series of step-down condensers for condensing and recovering liquid products from said vapor products.

7. The apparatus of claim **1** further including a wax collection takeoff port located between the mixing, molecular destabilization and heteroatom scavenging zone and the succeeding pyrolysis zone.

8. The apparatus of claim **1** wherein the sequence for mixing, destabilizing, desulfurizing, and dehalogenating said hydrocarbonaceous materials has a screw flight configuration of a ribbon mixer.

9. The apparatus of claim **1** further including a means for removing and collecting solid products wherein said solid products are char.

10. A pyrolysis process for conversion of hydrocarbonaceous material to produce useful vapor products and solid products comprising:

providing a generally cylindrical, linear reactor having a screw means for transporting said hydrocarbonaceous materials through said reactor, having means for heating said hydrocarbonaceous materials whereby they are processed and pyrolyzed to produce vapor products and solid products, zones that are maintained in the apparatus within defined ranges of temperature and defined residence times,

compressing said hydrocarbonaceous material to remove entrained air and moisture from said hydrocarbonaceous material,

melting said hydrocarbonaceous material,

mixing said melted hydrocarbonaceous material to form a melted mixture whereby said melted mixture is subject to molecular destabilization, dehalogenation, desulfurization, and heteroatom scavenging,

subjecting said melted hydrocarbonaceous material to pyrolysis to convert said hydrocarbonaceous material to vapor products and solid products, and

recovering said vapor products and said solid products,

wherein said screw means has a plurality of flight configurations for compressing said hydrocarbonaceous materials, for melting said hydrocarbonaceous materials to convert said hydrocarbonaceous materials from a solid to a liquid state, for mixing, destabilizing, desulfurizing, and dehalogenating said hydrocarbonaceous materials, for pyrolyzing said hydrocarbonaceous materials, for devolatilizing the pyrolyzed hydrocarbonaceous materials, and for discharging solid products from said hydrocarbonaceous materials.

11. The process of claim 10 wherein said hydrocarbonaceous material is fed to said reactor with finely divided, mineral-based additives selected from one or more melt-phase heteroatom scavengers selected from the group consisting of alkali metals, alkaline earth metals, transition metals, post-transition metals and metalloids, and mixtures thereof.

12. The process of claim 10 wherein said hydrocarbonaceous material is fed to said reactor with finely divided, mineral-based additives selected from (i) one or more melt-phase heteroatom scavengers selected from the group consisting of alkali metals, alkaline earth metals, transition metals, post-transition metals and metalloids, and mixtures thereof; and, (ii) one or more melt-phase catalysts selected from the group consisting of alkali metals, alkaline earth metals, transition metals, post-transition metals, metalloids, non-metals and silicate minerals, and mixtures thereof.

13. The process of claim 10 wherein the residence time in the compression zone is less than about one minute.

14. The process of claim 10 wherein the moisture is removed to about 10% moisture by weight.

15. The process of claim 10 wherein said hydrocarbonaceous materials are maintained in a melt zone at a temperature of about 220°F to 572°F to melt said hydrocarbonaceous materials.

16. The process of claim 10 wherein the residence time in the melt zone is about 15 minutes to 45 minutes.

17. The process of claim 10 wherein said hydrocarbonaceous materials are mixed, destabilized, desulfurized, and dehalogenated at a temperature in the range of about 572°F to 690°F.

18. The process of claim 10 wherein the residence time m the mixing, molecular destabilization and heteroatom scavenging zone is about 30 minutes to 120 minutes.

19. The process of claim 10 wherein the residence time in the feed zone is less than about one minute.

20. The process of claim 10 wherein the recovered solid products include microcrystalline wax and paraffin wax and mixtures thereof.

21. The process of claim 10 wherein the residence time in the pyrolysis zone is about 30 minutes to 90 minutes.

22. The process of claim 10 wherein said solid products are devolatilized at a temperature in the range of about 850°F to 1,800°F.

23. The process of claim 10 wherein the residence time in the devolatilization zone is about 15 minutes to 60 minutes.

24. The process of claim 10 wherein the residence time in the char discharge zone is about 15 minutes to 30 minutes.

25. The process of claim 10 wherein said hydrocarbonaceous materials are selected from the group consisting of plastic, thermoplastic polymer, thermoset polymer, hydrocarbon liquids, used oil, waste oil, gasoil, refinery bottoms, cylinder oil, waste elastomer, scrap tire, rubber residue, rubber belting, EPDM rubber sheet, membrane, and extrudate, and mixtures thereof.

26. The process of claim 10 further comprising condensing said vapor products to recover liquid products.

27. A process for conversion of hydrocarbonaceous material to produce useful wax products comprising:

providing a generally cylindrical, linear reactor having a screw means for transporting said hydrocarbonaceous materials through said reactor, having means for heating said hydrocarbonaceous materials whereby they are melted and processed to produce vapor products and solid products, wherein said solid products comprise one or more wax products, zones that are maintained in the apparatus within defined ranges of temperature and defined residence times,

feeding a mixture of hydrocarbonaceous material and heteroatom scavenging composition to said reactor,

compressing said hydrocarbonaceous material to remove entrained air and moisture from said hydrocarbonaceous material,

melting said hydrocarbonaceous material,

mixing said melted hydrocarbonaceous material to form a melted mixture whereby said melted mixture is subject to molecular destabilization, dehalogenation, and heteroatom scavenging,

recovering said wax products,

wherein said screw means has a plurality of flight configurations for compressing said hydrocarbonaceous materials, for melting said hydrocarbonaceous materials to convert said hydrocarbonaceous materials from a solid to a liquid state, for mixing, destabilizing, desulfurizing, and dehalogenating said hydrocarbonaceous materials, for pyrolyzing said hydrocarbonaceous materials, for devolatilizing the pyrolyzed hydrocarbonaceous materials, and for discharging solid products from said hydrocarbonaceous materials.

28. The process of claim 27 wherein said hydrocarbonaceous material is fed to said reactor with finely divided, mineral-based additives selected from (i) one or more melt-phase heteroatom scavengers selected from the group consisting of alkali metals, alkaline earth metals, transition metals, post-transition metals and metalloids, and mixtures thereof; and, (ii) one or more melt- phase catalysts selected from the group consisting of alkali metals, alkaline earth metals, transition metals, post-transition metals, metalloids, non-metals and silicate minerals, and mixtures thereof.

29. An apparatus for pyrolyzing hydrocarbonaceous materials comprising:

a reactor having a plurality of reactor zones in fluid communication with each other, wherein each zone has a configuration, and

a transportation device in communication with at least one of the plurality of reactor zones to transport the hydrocarbonaceous material through the reactor, wherein at least one portion of the transportation device has a configuration, and

wherein the configurations of the zones and the transportation device maintain the hydrocarbonaceous material for a predetermined residence time range and a predetermined temperature range, and

wherein the transportation device is a screw extending substantially through at least one of the plurality of reactor zones, and

wherein said screw has a plurality of flight configurations for compressing said hydrocarbonaceous materials, for melting said hydrocarbonaceous materials to convert said hydrocarbonaceous materials from a solid to a liquid state, for mixing, destabilizing, desulfurizing, and dehalogenating said hydrocarbonaceous materials, for pyrolyzing said hydrocarbonaceous materials, for devolatilizing the pyrolyzed hydrocarbonaceous materials, and for discharging solid products from said hydrocarbonaceous materials.

30. The apparatus of claim 29 wherein the respective flight configuration maintains the hydrocarbonaceous material within a reactor zone for a predetermined residence time range and a predetermined temperature range.

31. The apparatus of claim 29 wherein the reactor is substantially cylindrical and linear.

32. The apparatus of claim 29 wherein the reactor is oriented with respect to the horizon at an angle between about -20° to about +20°.

33. The apparatus of claim 32 wherein the reactor is oriented with respect to the horizon at an angle between about +2° to about +6°.

34. The apparatus of claim 32 wherein the reactor is oriented with respect to the horizon at an angle between about -2° to about -6°.

35. The apparatus of claim 29 wherein the plurality of reactor zones further comprise:

a reduction and compression zone,

a melt zone,

a mixing, destabilization and heteroatom scavenging zone,

a pyrolysis zone,

a devolatilization zone, and

wherein the zones are continuously and serially operated.

36. The apparatus of claim 35 wherein a temperature of the reduction and compression zone is between about ambient temperature to about 220°F.

37. The apparatus of claim 35 wherein a pressure of the reduction and compression zone is less than about 0.1 atm.

38. The apparatus of claim 35 wherein a residence time range of the reduction and compression zone is less than about 3 minutes.

39. The apparatus of claim 35 wherein a pitch ratio in the reduction and compression zone is between about 1.5 to about 2.0.

40. The apparatus of claim 35 wherein a temperature of the melt zone is between about 220°F to about 572°F.

41. The apparatus of claim 35 wherein a residence time range of the melt zone is between about 15 minutes to about 45 minutes.

42. The apparatus of claim 35 wherein a pitch ratio in the melt zone is between about 2.0 to about 5.0.

43. The apparatus of claim 42 wherein the pitch ratio in the melt zone is about 2.5.

44. The apparatus of claim 35 wherein a temperature range of the mixing, destabilization and heteroatom scavenging zone is between about 572°F to about 690°F.

45. The apparatus of claim 35 wherein a residence time range of the mixing, destabilization and heteroatom scavenging zone is between about 30 minutes to about 120 minutes.

46. The apparatus of claim 35 wherein the transportation device in the mixing, destabilization and heteroatom scavenging zone is a ribbon mixer.

47. The apparatus of claim 35 wherein the lower end of a temperature range of the pyrolysis zone is between about 690°F to about 740°F, the upper end of the temperature range of the pyrolysis zone is between about 850°F to about 910°F.

48. The apparatus of claim 35 wherein a pressure of the pyrolysis zone is not more than about 5.0 psig.

49. The apparatus of claim 35 wherein a residence time range of the pyrolysis zone is between about 30 minutes to about 90 minutes.

50. The apparatus of claim 35 wherein a pitch ratio in the pyrolysis zone is between about 2.0 to about 5.0.

51. The apparatus of claim 50 wherein the pitch ratio in the pyrolysis zone is between about 2.5 to about 3.0.

52. The apparatus of claim 35 wherein the lower end of a temperature range of the devolatilization zone is between about 850°F to about 910°F, the temperature range of the devolatilization zone is not greater than about 1800°F.

53. The apparatus of claim 52 wherein the temperature range of the devolatilization zone is between about 1100°F to about 1200°F.

54. The apparatus of claim 35 wherein a pressure of the devolatilization zone is not more than about 5.0 psig.

55. The apparatus of claim 54 wherein the pressure of the devolatilization zone is not more than about 0.8 psig.

56. The apparatus of claim 35 wherein a residence time range of the devolatilization zone is between about 15 minutes to about 60 minutes.

57. The apparatus of claim 35 wherein a pitch ratio in the devolatilization zone is between about 2.0 to about 5.0.

58. The apparatus of claim 57 wherein the pitch ratio in the devolatilization zone is between about 2.5 to about 3.0.

59. A pyrolysis process for conversion of hydrocarbonaceous material, comprising:

continuously transporting the hydrocarbonaceous material via a transportation device of a reactor,

maintaining the hydrocarbonaceous material through a plurality of zones of the reactor for respective predetermined residence times and respective predetermined temperature ranges, and

pyrolyzing the hydrocarbonaceous material into hydrocarbon products,

wherein the transportation device is a screw extending substantially through at least one of the plurality of reactor zones, and

wherein said screw has a plurality of flight configurations for compressing said hydrocarbonaceous materials, for melting said hydrocarbonaceous materials to convert said hydrocarbonaceous materials from a solid to a liquid state, for mixing, destabilizing, desulfurizing,

and dehalogenating said hydrocarbonaceous materials, for pyrolyzing said hydrocarbonaceous materials, for devolatilizing the pyrolyzed hydrocarbonaceous materials, and for discharging solid products from said hydrocarbonaceous materials.

60. The pyrolysis process of claim 59 further comprising:
compressing the hydrocarbonaceous material volume,
melting the hydrocarbonaceous material,
mixing, destabilizing and scavenging heteroatom, and
devolatilizing char and residual solids.

CLAIMS

What is claimed is:

1. An apparatus for pyrolyzing hydrocarbonaceous materials to produce useful vapor products and solid products comprising:

a generally cylindrical, linear reactor having a screw means for transporting said hydrocarbonaceous materials through said reactor,

means for feeding hydrocarbonaceous materials to said reactor,

means for heating said hydrocarbonaceous materials whereby they are processed and pyrolyzed to produce vapor products and solid products,

wherein said screw means extends substantially the length of said linear reactor;

wherein said screw means has zones for advancing and mixing hydrocarbonaceous material in the reactor,

means for removing vapor products from said processed hydrocarbonaceous materials in said reactor,

means for removing solid products from said reactor,

wherein said reactor has zones that are maintained in the apparatus within defined ranges of temperature,

means whereby said hydrocarbonaceous material is maintained within a zone for a range of defined residence times,

wherein said zones collectively comprise the complete environments required for pyrolysis,

means for rotating said screw,

wherein said screw means has a plurality of flight configurations for compressing said hydrocarbonaceous materials, for melting said hydrocarbonaceous materials to convert said hydrocarbonaceous materials from a solid to a liquid state, for mixing, destabilizing, desulfurizing, and dehalogenating said hydrocarbonaceous materials, for pyrolyzing said hydrocarbonaceous materials, for devolatilizing the pyrolyzed hydrocarbonaceous materials, and for discharging solid products from said hydrocarbonaceous materials.

2. The apparatus of claim **1** wherein the means for removing moisture from said hydrocarbonaceous material includes means for compressing and heating said hydrocarbonaceous materials to remove air and moisture from said hydrocarbonaceous materials.

3. The apparatus of claim **1** wherein the flight configurations of said screw incorporates a ribbon mixer.

4. The apparatus of claim **1** wherein said reactor is oriented with respect to the horizon at an angle between about -20° to about +20°, preferably in an incline between about +2° to about +6°.

5. The apparatus of claim **1** wherein said reactor is oriented with respect to the horizon at an angle between about -20° to about +20°, preferably in a decline between about -2° to about -6°.

6. The apparatus of claim **1** further comprising a series of step-down condensers for condensing and recovering liquid products from said vapor products.

7. The apparatus of claim **1** further including a wax collection takeoff port located between the mixing, molecular destabilization and heteroatom scavenging zone and the succeeding pyrolysis zone.

8. The apparatus of claim **1** wherein the sequence for mixing, destabilizing, desulfurizing, and dehalogenating said hydrocarbonaceous materials has a screw flight configuration of a ribbon mixer.

9. The apparatus of claim **1** further including a means for removing and collecting solid products wherein said solid products are char.

10. A pyrolysis process for conversion of hydrocarbonaceous material to produce useful vapor products and solid products comprising:

providing a generally cylindrical, linear reactor having a screw means for transporting said hydrocarbonaceous materials through said reactor, having means for heating said hydrocarbonaceous materials whereby they are processed and pyrolyzed to produce vapor products and solid products, zones that are maintained in the apparatus within defined ranges of temperature and defined residence times,

compressing said hydrocarbonaceous material to remove entrained air and moisture from said hydrocarbonaceous material,

melting said hydrocarbonaceous material,

mixing said melted hydrocarbonaceous material to form a melted mixture whereby said melted mixture is subject to molecular destabilization, dehalogenation, desulfurization, and heteroatom scavenging,

subjecting said melted hydrocarbonaceous material to pyrolysis to convert said hydrocarbonaceous material to vapor products and solid products, and

recovering said vapor products and said solid products,

wherein said screw means has a plurality of flight configurations for compressing said hydrocarbonaceous materials, for melting said hydrocarbonaceous materials to convert said hydrocarbonaceous materials from a solid to a liquid state, for mixing, destabilizing, desulfurizing, and dehalogenating said hydrocarbonaceous materials, for pyrolyzing said hydrocarbonaceous materials, for devolatilizing the pyrolyzed hydrocarbonaceous materials, and for discharging solid products from said hydrocarbonaceous materials.

11. The process of claim 10 wherein said hydrocarbonaceous material is fed to said reactor with finely divided, mineral-based additives selected from one or more melt-phase heteroatom scavengers selected from the group consisting of alkali metals, alkaline earth metals, transition metals, post-transition metals and metalloids, and mixtures thereof.

12. The process of claim 10 wherein said hydrocarbonaceous material is fed to said reactor with finely divided, mineral-based additives selected from (i) one or more melt-phase heteroatom scavengers selected from the group consisting of alkali metals, alkaline earth metals, transition metals, post-transition metals and metalloids, and mixtures thereof; and, (ii) one or more melt-phase catalysts selected from the group consisting of alkali metals, alkaline earth metals, transition metals, post-transition metals, metalloids, non-metals and silicate minerals, and mixtures thereof.

13. The process of claim 10 wherein the residence time in the compression zone is less than about one minute.

14. The process of claim 10 wherein the moisture is removed to about 10% moisture by weight.

15. The process of claim 10 wherein said hydrocarbonaceous materials are maintained in a melt zone at a temperature of about 220°F to 572°F to melt said hydrocarbonaceous materials.

16. The process of claim 10 wherein the residence time in the melt zone is about 15 minutes to 45 minutes.

17. The process of claim 10 wherein said hydrocarbonaceous materials are mixed, destabilized, desulfurized, and dehalogenated at a temperature in the range of about 572°F to 690°F.

18. The process of claim 10 wherein the residence time m the mixing, molecular destabilization and heteroatom scavenging zone is about 30 minutes to 120 minutes.

19. The process of claim 10 wherein the residence time in the feed zone is less than about one minute.

20. The process of claim 10 wherein the recovered solid products include microcrystalline wax and paraffin wax and mixtures thereof.

21. The process of claim 10 wherein the residence time in the pyrolysis zone is about 30 minutes to 90 minutes.

22. The process of claim 10 wherein said solid products are devolatilized at a temperature in the range of about 850°F to 1,800°F.

23. The process of claim 10 wherein the residence time in the devolatilization zone is about 15 minutes to 60 minutes.

24. The process of claim 10 wherein the residence time in the char discharge zone is about 15 minutes to 30 minutes.

25. The process of claim 10 wherein said hydrocarbonaceous materials are selected from the group consisting of plastic, thermoplastic polymer, thermoset polymer, hydrocarbon liquids, used oil, waste oil, gasoil, refinery bottoms, cylinder oil, waste elastomer, scrap tire, rubber residue, rubber belting, EPDM rubber sheet, membrane, and extrudate, and mixtures thereof.

26. The process of claim 10 further comprising condensing said vapor products to recover liquid products.

27. A process for conversion of hydrocarbonaceous material to produce useful wax products comprising:

providing a generally cylindrical, linear reactor having a screw means for transporting said hydrocarbonaceous materials through said reactor, having means for heating said hydrocarbonaceous materials whereby they are melted and processed to produce vapor products and solid products, wherein said solid products comprise one or more wax products, zones that are maintained in the apparatus within defined ranges of temperature and defined residence times,

feeding a mixture of hydrocarbonaceous material and heteroatom scavenging composition to said reactor,

compressing said hydrocarbonaceous material to remove entrained air and moisture from said hydrocarbonaceous material,

melting said hydrocarbonaceous material,

mixing said melted hydrocarbonaceous material to form a melted mixture whereby said melted mixture is subject to molecular destabilization, dehalogenation, and heteroatom scavenging,

recovering said wax products,

wherein said screw means has a plurality of flight configurations for compressing said hydrocarbonaceous materials, for melting said hydrocarbonaceous materials to convert said hydrocarbonaceous materials from a solid to a liquid state, for mixing, destabilizing, desulfurizing, and dehalogenating said hydrocarbonaceous materials, for pyrolyzing said hydrocarbonaceous materials, for devolatilizing the pyrolyzed hydrocarbonaceous materials, and for discharging solid products from said hydrocarbonaceous materials.

28. The process of claim 27 wherein said hydrocarbonaceous material is fed to said reactor with finely divided, mineral-based additives selected from (i) one or more melt-phase heteroatom scavengers selected from the group consisting of alkali metals, alkaline earth metals, transition metals, post-transition metals and metalloids, and mixtures thereof; and, (ii) one or more melt- phase catalysts selected from the group consisting of alkali metals, alkaline earth metals, transition metals, post-transition metals, metalloids, non-metals and silicate minerals, and mixtures thereof.

29. An apparatus for pyrolyzing hydrocarbonaceous materials comprising:

a reactor having a plurality of reactor zones in fluid communication with each other, wherein each zone has a configuration, and

a transportation device in communication with at least one of the plurality of reactor zones to transport the hydrocarbonaceous material through the reactor, wherein at least one portion of the transportation device has a configuration, and

wherein the configurations of the zones and the transportation device maintain the hydrocarbonaceous material for a predetermined residence time range and a predetermined temperature range, and

wherein the transportation device is a screw extending substantially through at least one of the plurality of reactor zones, and

wherein said screw has a plurality of flight configurations for compressing said hydrocarbonaceous materials, for melting said hydrocarbonaceous materials to convert said hydrocarbonaceous materials from a solid to a liquid state, for mixing, destabilizing, desulfurizing, and dehalogenating said hydrocarbonaceous materials, for pyrolyzing said hydrocarbonaceous materials, for devolatilizing the pyrolyzed hydrocarbonaceous materials, and for discharging solid products from said hydrocarbonaceous materials.

30. The apparatus of claim 29 wherein the respective flight configuration maintains the hydrocarbonaceous material within a reactor zone for a predetermined residence time range and a predetermined temperature range.

31. The apparatus of claim 29 wherein the reactor is substantially cylindrical and linear.

32. The apparatus of claim 29 wherein the reactor is oriented with respect to the horizon at an angle between about -20° to about +20°.

33. The apparatus of claim 32 wherein the reactor is oriented with respect to the horizon at an angle between about +2° to about +6°.

34. The apparatus of claim 32 wherein the reactor is oriented with respect to the horizon at an angle between about -2° to about -6°.

35. The apparatus of claim 29 wherein the plurality of reactor zones further comprise:
a reduction and compression zone,
a melt zone,
a mixing, destabilization and heteroatom scavenging zone,
a pyrolysis zone,
a devolatilization zone, and
wherein the zones are continuously and serially operated.

36. The apparatus of claim 35 wherein a temperature of the reduction and compression zone is between about ambient temperature to about 220°F.

37. The apparatus of claim 35 wherein a pressure of the reduction and compression zone is less than about 0.1 atm.

38. The apparatus of claim 35 wherein a residence time range of the reduction and compression zone is less than about 3 minutes.

39. The apparatus of claim 35 wherein a pitch ratio in the reduction and compression zone is between about 1.5 to about 2.0.

40. The apparatus of claim 35 wherein a temperature of the melt zone is between about 220°F to about 572°F.

41. The apparatus of claim 35 wherein a residence time range of the melt zone is between about 15 minutes to about 45 minutes.

42. The apparatus of claim 35 wherein a pitch ratio in the melt zone is between about 2.0 to about 5.0.

43. The apparatus of claim 42 wherein the pitch ratio in the melt zone is about 2.5.

44. The apparatus of claim 35 wherein a temperature range of the mixing, destabilization and heteroatom scavenging zone is between about 572°F to about 690°F.

45. The apparatus of claim 35 wherein a residence time range of the mixing, destabilization and heteroatom scavenging zone is between about 30 minutes to about 120 minutes.

46. The apparatus of claim 35 wherein the transportation device in the mixing, destabilization and heteroatom scavenging zone is a ribbon mixer.

47. The apparatus of claim 35 wherein the lower end of a temperature range of the pyrolysis zone is between about 690°F to about 740°F, the upper end of the temperature range of the pyrolysis zone is between about 850°F to about 910°F.

48. The apparatus of claim 35 wherein a pressure of the pyrolysis zone is not more than about 5.0 psig.

49. The apparatus of claim 35 wherein a residence time range of the pyrolysis zone is between about 30 minutes to about 90 minutes.

50. The apparatus of claim 35 wherein a pitch ratio in the pyrolysis zone is between about 2.0 to about 5.0.

51. The apparatus of claim 50 wherein the pitch ratio in the pyrolysis zone is between about 2.5 to about 3.0.

52. The apparatus of claim 35 wherein the lower end of a temperature range of the devolatilization zone is between about 850°F to about 910°F, the temperature range of the devolatilization zone is not greater than about 1800°F.

53. The apparatus of claim 52 wherein the temperature range of the devolatilization zone is between about 1100°F to about 1200°F.

54. The apparatus of claim 35 wherein a pressure of the devolatilization zone is not more than about 5.0 psig.

55. The apparatus of claim 54 wherein the pressure of the devolatilization zone is not more than about 0.8 psig.

56. The apparatus of claim 35 wherein a residence time range of the devolatilization zone is between about 15 minutes to about 60 minutes.

57. The apparatus of claim 35 wherein a pitch ratio in the devolatilization zone is between about 2.0 to about 5.0.

58. The apparatus of claim 57 wherein the pitch ratio in the devolatilization zone is between about 2.5 to about 3.0.

59. A pyrolysis process for conversion of hydrocarbonaceous material, comprising:

continuously transporting the hydrocarbonaceous material via a transportation device of a reactor,

maintaining the hydrocarbonaceous material through a plurality of zones of the reactor for respective predetermined residence times and respective predetermined temperature ranges, and

pyrolyzing the hydrocarbonaceous material into hydrocarbon products,

wherein the transportation device is a screw extending substantially through at least one of the plurality of reactor zones, and

wherein said screw has a plurality of flight configurations for compressing said hydrocarbonaceous materials, for melting said hydrocarbonaceous materials to convert said hydrocarbonaceous materials from a solid to a liquid state, for mixing, destabilizing, desulfurizing,

and dehalogenating said hydrocarbonaceous materials, for pyrolyzing said hydrocarbonaceous materials, for devolatilizing the pyrolyzed hydrocarbonaceous materials, and for discharging solid products from said hydrocarbonaceous materials.

60. The pyrolysis process of claim 59 further comprising:
compressing the hydrocarbonaceous material volume,
melting the hydrocarbonaceous material,
mixing, destabilizing and scavenging heteroatom, and
devolatilizing char and residual solids.