CLAIMS

What is claimed:

1. An integrated pyrolysis and hydrocracking process for converting a hydrocarbon mixture to produce olefins, the process comprising:

   mixing a whole crude and a gas oil to form a hydrocarbon mixture;

   heating the hydrocarbon mixture in a heater to vaporize a portion of the hydrocarbons in the hydrocarbon mixture and form a heated hydrocarbon mixture;

   separating the heated hydrocarbon mixture, in a first separator, into a first vapor fraction and a first liquid fraction;

   mixing steam with the first vapor fraction, superheating the resulting mixture in the convection zone, and feeding the superheated mixture to a first radiant coil in a radiant zone of the pyrolysis reactor;

   feeding the first liquid fraction, or a portion thereof, and hydrogen to a hydrocracking reactor system, contacting the first liquid fraction with a hydrocracking catalyst to crack a portion of the hydrocarbons in the first liquid fraction, and recovering an effluent from the hydrocracking reactor system;

   separating unreacted hydrogen from the hydrocarbons in the effluent;

   fractionating the effluent hydrocarbons to form two or more hydrocarbon fractions including the gas oil.

2. An integrated pyrolysis and hydrocracking process for converting a hydrocarbon mixture to produce olefins, the process comprising:

   mixing a whole crude and a gas oil to form a hydrocarbon mixture;

   heating the hydrocarbon mixture in a heater to vaporize a portion of the hydrocarbons in the hydrocarbon mixture and form a heated hydrocarbon mixture;

   separating the heated hydrocarbon mixture, in a first separator, into a first vapor fraction and a first liquid fraction;

   heating the first liquid fraction in a convection zone of a pyrolysis reactor to vaporize a portion of the hydrocarbons in the first liquid fraction and form a second heated hydrocarbon mixture;

   separating the second heated hydrocarbon mixture, in a second separator, into a second vapor fraction and a second liquid fraction;

mixing steam with the first vapor fraction, superheating the resulting mixture in the convection zone, and feeding the superheated mixture to a first radiant coil in a radiant zone of the pyrolysis reactor; and

mixing steam with the second vapor fraction, superheating the resulting mixture in the convection zone, and feeding the superheated mixture to a second radiant coil in a radiant zone of the pyrolysis reactor;

feeding the second liquid fraction, or a portion thereof, and hydrogen to a hydrocracking reactor system, contacting the second liquid fraction with a hydrocracking catalyst to crack a portion of the hydrocarbons in the second liquid fraction, and recovering an effluent from the hydrocracking reactor system;

separating unreacted hydrogen from the hydrocarbons in the effluent;

fractionating the effluent hydrocarbons to form two or more hydrocarbon fractions including the gas oil and a residue fraction.

3. The process of claim 1, further comprising mixing the first liquid fraction with steam prior to heating the first liquid fraction in the convection zone.
4. The process of claim 1, further comprising feeding steam to at least one of the first and second separators.
5. The process of claim 2, further comprising:

mixing the second liquid fraction with steam to form a steam/oil mixture;

heating the steam/oil mixture in the convection zone of the pyrolysis reactor to vaporize a portion of the hydrocarbons in the steam/oil mixture and form a third heated hydrocarbon mixture;

separating the third heated hydrocarbon mixture, in a third separator, into a third vapor fraction and a third liquid fraction;

mixing steam with the third vapor fraction, superheating the resulting mixture in the convection zone, and feeding the superheated mixture to a third radiant coil in a radiant zone of the pyrolysis reactor.

6. The process of claim 5, further comprising

withdrawing a portion of a steam stream and using the portion as the steam for mixing with at least one of the hydrocarbon mixture, the first liquid fraction, the first vapor fraction, and the second liquid fraction;

superheating a remaining portion of the steam stream in the convection zone of the pyrolysis reactor; and

feeding the superheated steam to at least one of the first separator, the second separator, and the third separator.

7. The process of claim 6, further comprising using a portion of the superheated steam as the steam for mixing with the third vapor fraction.
8. The process of claim 5, wherein a temperature of a flue gas in the convection zone is higher when heating the second liquid fraction than when heating the first liquid fraction.
9. The process of claim 8, wherein a temperature of the flue gas in the convection zone is higher when superheating the first, second, and third vapor fractions than when heating the second liquid fraction.
10. The process of claim 1, wherein the hydrocarbon mixture comprises a whole crude and/or a gas oil including hydrocarbons having a normal boiling point of at least 550°C.
11. A process for producing olefins and/or dienes, the process comprising:

partially vaporizing a whole crude to form a liquid fraction and a vapor fraction;

superheating the vapor fraction;

thermally cracking the superheated vapor fraction to produce a cracked hydrocarbon effluent containing a mixture of olefins and paraffins;

hydrocracking at least a portion of the liquid fraction to produce a hydrocracked hydrocarbon effluent containing additional olefins and/or dienes;

separating the hydrocracked hydrocarbon effluent to recover two or more hydrocarbon fractions including a gas oil fraction; and mixing the gas oil fraction with the whole crude prior to the partially vaporizing step.

12. The process of claim 11, further comprising mixing steam with the vapor fraction prior to the superheating step.
13. The process of claim 11, further comprising:

partially vaporizing the liquid fraction to form a second liquid fraction and a second vapor fraction;

superheating the second vapor fraction;

thermally cracking the superheated vapor fraction to produce a second cracked hydrocarbon effluent containing a mixture of olefins and paraffins; and

feeding the second liquid fraction to the hydrocracking step as the at least a portion of the liquid fraction.

14. The process of claim 11, further comprising mixing steam with and separating the partially vaporized whole crude to form the liquid fraction and the vapor fraction.

15. A system for producing olefins and/or dienes, the system comprising:

a pyrolysis heater comprising a convection heating zone and a radiant heating zone;

a heating coil in the convection heating zone for partially vaporizing a whole crude to form a liquid fraction and a vapor fraction;

a second heating coil in the convection heating zone for superheating the vapor fraction;

a radiant heating coil in the radiant heating zone for thermally cracking the superheated vapor fraction to produce a cracked hydrocarbon effluent containing a mixture of olefins and paraffins;

a hydrocracking reaction zone for hydrocracking at least a portion of the liquid fraction to produce a hydrocracked hydrocarbon effluent containing additional olefins and/or dienes;

a separator for separating the hydrocracked hydrocarbon effluent to recover two or more hydrocarbon fractions including a gas oil fraction; and a means for mixing the gas oil fraction with the whole crude upstream of the heating coil.

16. The system of claim 15, further comprising means for mixing steam with the vapor fraction upstream of the second heating coil.

17. The system of claim 15, further comprising:

a third heating coil in the convection heating zone for partially vaporizing the liquid fraction to form a second liquid fraction and a second vapor fraction;

a fourth heating coil in the convection heating zone for superheating the second vapor fraction;

a second radiant heating coil in the radiant heating zone for thermally cracking the superheated vapor fraction to produce a second cracked hydrocarbon effluent containing a mixture of olefins and paraffins; and

a flow line for feeding the second liquid fraction to the hydrocracking step as the at least a portion of the liquid fraction.

18. The system of claim 17, further comprising means for mixing steam with and separating the partially vaporized liquid fraction to form the second liquid fraction and the second vapor fraction.

19. The system of claim 15, further comprising means for mixing steam with and separating the partially vaporized whole crude to form the liquid fraction and the vapor fraction.
20. A process for producing olefins and/or dienes, the process comprising: partially vaporizing a whole crude to form a liquid fraction and a vapor fraction; superheating the vapor fraction to form a superheated vapor fraction; hydrotreating the liquid fraction to remove one or more of metals, sulfur, nitrogen, Conradson Carbon Residue (CCR), or asphaltenes to produce a hyrotreated liquid; partially vaporizing the hydrotreated liquid to form a second vapor fraction and a second liquid fraction; partially vaporizing the second liquid fraction to form a third vapor fraction and a third liquid fraction; hydrocracking the third liquid fraction to convert hydrocarbon components therein having a boiling point greater than 550°C to hydrocarbons having a boiling point of less than 550°C and recovering a hydrocracked effluent; separating the hydrocracked effluent to recover a light hydrocracked fraction and a heavy hydrocracked fraction; hydrocracking the heavy hydrocracked fraction to convert hydrocarbon components therein to naphtha range hydrocarbons and to recover a second hydrocracked effluent; separating the second hydrocracked effluent to recover a second light hydrocracked fraction, comprising the naphtha range hydrocarbons, and a second heavy hydrocracked fraction; partially vaporizing the second heavy hydrocracked fraction to recover a fourth vapor fraction and a fourth liquid fraction; thermally cracking (i) the superheated vapor fraction, (ii) the third vapor fraction; (iii) the second vapor fraction, (iv) the fourth vapor fraction, (v) the second light hydrocracked fraction and (vi) the fourth liquid fraction, to produce thermally cracked hydrocarbon effluents each containing a mixture of olefins and paraffins.
21. The process of claim 20, wherein the thermally cracking comprises collectively thermally cracking the superheated vapor fraction, the second vapor fraction, and the second Mr. Yong-Soo Oh July 6, 2021 Page 4 3910097 light hydrocracked fraction, the process further comprising mixing the superheated vapor fraction, the second vapor fraction, and the second light hydrocracked fraction.
22. The process of claim 20, wherein the thermally cracking comprises collectively thermally cracking the third vapor fraction and the fourth vapor fraction, the process further comprising mixing the third vapor fraction and the fourth vapor fraction.
23. The process of claim 20, wherein the hydrotreating further comprises hydrotreating the light hydrocracked fraction.

24. The process of claim 22, further comprising separating the thermally cracked hydrocarbon effluents to recover one or more light olefins fractions and a fraction boiling above 370°C.
25. The process of claim 26, wherein the hydrocracking the third liquid fraction and/or the hydrocracking the heavy hydrocracked fraction further comprises hydrocracking the fraction boiling above 370°C.
26. A process for producing olefins and/or dienes, the process comprising: partially vaporizing a whole crude to form a liquid fraction and a vapor fraction; superheating the vapor fraction to form a superheated vapor fraction; hydrotreating the liquid fraction to remove one or more of metals, sulfur, nitrogen, Conradson Carbon Residue (CCR), or asphaltenes to produce a hyrotreated liquid; partially vaporizing the hydrotreated liquid to form a second vapor fraction and a second liquid fraction; partially vaporizing the second liquid fraction to form a third vapor fraction and a third liquid fraction; hydrocracking the third liquid fraction to convert hydrocarbon components therein having a boiling point greater than 550°C to hydrocarbons having a boiling point of less than 550°C and recovering a hydrocracked effluent; separating the hydrocracked effluent to recover a light hydrocracked fraction and a heavy hydrocracked fraction; hydrocracking the heavy hydrocracked fraction to convert hydrocarbon components therein to naphtha range hydrocarbons and to recover a second hydrocracked effluent; separating the second hydrocracked effluent to recover a second light hydrocracked fraction, comprising the naphtha range hydrocarbons, and a second heavy hydrocracked fraction; thermally cracking (i) the superheated vapor fraction, (ii) the third vapor fraction; (iii) the second vapor fraction, (iv) the second heavy hydrocracked fraction, and (v) the second light hydrocracked fraction, to produce thermally cracked hydrocarbon effluents each containing a mixture of olefins and paraffins.
27. The process of claim 28, wherein the thermally cracking comprises collectively thermally cracking the superheated vapor fraction, the second vapor fraction, and the second light hydrocracked fraction, the process further comprising mixing the superheated vapor fraction, the second vapor fraction, and the second light hydrocracked fraction.
28. The process of claim 28, wherein the hydrotreating further comprises hydrotreating the light hydrocracked fraction.

29. The process of claim 28, further comprising separating the thermally cracked hydrocarbon effluents to recover one or more light olefins fractions and a fraction boiling above 370°C.
30. The process of claim 31, wherein the hydrocracking the third liquid fraction and/or the hydrocracking the heavy hydrocracked fraction further comprises hydrocracking the fraction boiling above 370°C.