CLAIMS

What is claimed as new and desired to be protected by Letters Patent is:

1. A system useful for catalytic cracking of a whole crude, the system comprising:

a separator for separating a whole crude into a light boiling fraction and a heavy boiling fraction;

a first two-reactor dual-catalyst system and a second two-reactor dual-catalyst system, each producing a converted hydrocarbon effluent;

a common fractionation system for receiving the converted hydrocarbon effluent from each of the first two-reactor dual catalyst system and the second two-reactor dual catalyst system, the common fractionation system configured to separate the converted hydrocarbon fractions into two or more hydrocarbon fractions including one or more olefin containing fractions and a treated fluid catalytic cracking feedstock;

the first two-reactor dual-catalyst system, wherein the first two-reactor dual-catalyst system is configured for contacting the heavy boiling fraction with a residue fluid catalytic cracking catalyst and for contacting contaminated residue fluid catalytic cracking catalyst with a metal trap; and

the second two-reactor dual-catalyst system, wherein the second two-reactor dual catalyst comprises:

a first reactor for contacting the treated fluid catalytic cracking feedstock with a mixed catalyst system comprising a first catalyst and a second catalyst;

a second reactor for contacting the light boiling fraction with a mixed catalyst system comprising the first catalyst and the second catalyst, wherein the first catalyst is at a higher relative concentration in the second reactor compared to the first reactor; and

a catalyst disengagement vessel configured to receive and separate an effluent from each of the first and second reactors into a spent catalyst mixture and

the converted hydrocarbon effluent from the second two-reactor dual catalyst system fed to the common fractionation system.

2. The system of claim 1, wherein the separator for separating a whole crude into a light boiling fraction and a heavy boiling fraction is configured to separate a light boiling fraction having a 95% end boiling temperature in the range from about 300°C to about 420°C from the heavy boiling fraction.

3. The system of claim 1, wherein the second two-reactor dual catalyst system comprises:

a regenerator for regenerating spent first catalyst and spent second catalyst, and including a first outlet for conveying a mixture of regenerated first and second catalyst and a second outlet for conveying a mixture of regenerated first and second catalyst;

the first reactor, wherein the first reactor is a riser reactor for contacting the heavy boiling fraction with the mixture of regenerated first and second catalyst, wherein the first catalyst has a density greater than a density of the second catalyst, a particle size larger than a particle size of the second catalyst, or both a greater density and a larger particle size than the second catalyst, the riser reactor having:

an inlet for receiving the catalyst mixture comprising regenerated first and second catalyst from the regenerator; and

an outlet for conveying a mixture of converted hydrocarbons and the catalyst mixture;

the second reactor, wherein the second reactor is a moving or fluidized bed reactor for contacting the light boiling fraction with a concentrated catalyst mixture comprising first catalyst and second catalyst, the second reactor having:

an inlet for receiving the catalyst mixture comprising regenerated first and second catalyst from the regenerator;

an outlet for conveying a mixture of converted hydrocarbons, first catalyst and second catalyst to a catalyst separation system, the catalyst separation system configured to:

separate the first catalyst from a mixture comprising the second catalyst and the converted hydrocarbons based on at least one of catalyst size or catalyst density;

produce a first stream comprising separated first catalyst and a second stream comprising the second catalyst and the converted hydrocarbons; and

an inlet for receiving the first stream comprising the separated first catalyst thereby increasing a relative concentration of the first catalyst in the second reactor;

a disengagement vessel having one or more inlets for receiving (i) the second stream comprising the second catalyst and the converted hydrocarbons and (ii) the mixture of converted hydrocarbons and the catalyst mixture, the disengagement vessel configured to separate and recover a first effluent comprising converted hydrocarbons and a second effluent comprising a mixture of spent first and second catalyst; and

a flow line for conveying the mixture of spent first and second catalyst to the regenerator.

4. The system of claim 1, wherein the first two-reactor dual catalyst system comprises:

a first reactor for contacting the residue fluid catalytic cracking catalyst with a heavier boiling fraction hydrocarbon feedstock to convert at least a portion of the hydrocarbon feedstock to lighter hydrocarbons;

a separator for separating hydrocarbon product vapors, including the lighter hydrocarbons, from spent residue fluid catalytic cracking catalyst;

a feed line for feeding separated spent cracking catalyst from the separator to a catalyst regenerator;

a catalyst transfer line for transferring a portion of the spent cracking catalyst from the catalyst regenerator to a contaminant removal vessel;

the contaminant removal vessel, for contacting the spent catalyst with a contaminant trapping additive having at least one of an average particle size or density greater than an average particle size or density of the residue fluid catalytic cracking catalyst;

a second separator for separating an overhead stream from the contaminant removal vessel into a first stream comprising residue fluid catalytic cracking catalyst and lifting gas and a second stream comprising contaminant trapping additive;

a recycle line for transferring contaminant trapping additive recovered in the second separator to the contaminant removal vessel;

a bottoms product line for recovering contaminant trapping additive from the contaminant removal vessel; and

a line for transferring the first stream to the catalyst regenerator.

5. The system of claim 1, wherein the separator for separating the whole crude comprises a hot oil processing system.

6. The system of claim 1, wherein the common fractionation system is configured to separate the converted hydrocarbon fractions into three or more hydrocarbon fractions, the three or more hydrocarbon fractions including the one or more olefin fractions, the treated fluid catalytic cracking feedstock, and one or more of a C5 fraction, a FCC naphtha fraction, a heavy naphtha fraction, a light cycle oil fraction, or a slurry oil fraction.

7. The system of claim 6, further comprising a flow line for feeding the FCC naphtha fraction to the second reactor.

8. The system of claim 6, further comprising an olefins conversion unit for receiving at least one of the C4 fraction and the C5 fraction and for converting at least one of olefins or paraffins therein to at least one of ethylene or propylene.

9. The system of claim 6, further comprising an aromatics complex configured to reform the heavy naphtha fraction and to recover one or more aromatics product streams.

10. The system of claim 1, further comprising a second separator for separating the heavy boiling fraction into a medium boiling fraction and a residue fraction, wherein the residue fraction is fed as the heavy boiling fraction to the first two-reactor dual catalyst system, and wherein the medium boiling fraction is fed to the first reactor of the second two-reactor dual-catalyst system.

11. A process for catalytic cracking of a whole crude, the process comprising:

separating a whole crude into a light boiling fraction and a heavy boiling fraction;

converting the heavy boiling fraction in a first two-reactor dual-catalyst system and recovering a converted hydrocarbon effluent;

converting the light boiling fraction in a second two-reactor dual-catalyst system and recovering a converted hydrocarbon effluent;

separating the converted hydrocarbon effluent from each of the first two-reactor dual catalyst system and the second two-reactor dual catalyst system in a common fractionation system configured to separate the converted hydrocarbon fractions into two or more hydrocarbon fractions including one or more olefin containing fractions and a treated fluid catalytic cracking feedstock;

wherein the converting the heavy boiling fraction in a first two-reactor dual-catalyst system comprises contacting the heavy boiling fraction with a residue fluid catalytic cracking catalyst and contacting contaminated residue fluid catalytic cracking catalyst with a metal trap; and

wherein converting the light boiling fraction in a second two-reactor dual-catalyst system comprises:

contacting the treated fluid catalytic cracking feedstock with a mixed catalyst system comprising a first catalyst and a second catalyst in a first reactor;

contacting the light boiling fraction with a mixed catalyst system comprising the first catalyst and the second catalyst in a second reactor, wherein the first catalyst is at a higher relative concentration in the second reactor compared to the first reactor; and

separate an effluent from each of the first and second reactors into a spent catalyst mixture and the converted hydrocarbon effluent from the second two-reactor dual-catalyst system fed to the common fractionation system.

12. The process of claim 11, wherein the separating a whole crude into a light boiling fraction and a heavy boiling fraction comprises separating a light boiling fraction having a 95% end boiling temperature in the range from about 300°C to about 420°C from the heavy boiling fraction.

13. The process of claim 11, wherein the second two-reactor dual catalyst system comprises:

a regenerator for regenerating spent first catalyst and spent second catalyst, and including a first outlet for conveying a mixture of regenerated first and second catalyst and a second outlet for conveying a mixture of regenerated first and second catalyst;

the first reactor, wherein the first reactor is a riser reactor for contacting the heavy boiling fraction with the mixture of regenerated first and second catalyst, wherein the first catalyst has a density greater than a density of the second catalyst, a particle size larger than a particle size of the second catalyst, or both a greater density and a larger particle size than the second catalyst, the riser reactor having:

an inlet for receiving the catalyst mixture comprising regenerated first and second catalyst from the regenerator; and

an outlet for conveying a mixture of converted hydrocarbons and the catalyst mixture;

the second reactor, wherein the second reactor is a moving or fluidized bed reactor for contacting the light boiling fraction with a concentrated catalyst mixture comprising first catalyst and second catalyst, the second reactor having:

an inlet for receiving the catalyst mixture comprising regenerated first and second catalyst from the regenerator;

an outlet for conveying a mixture of converted hydrocarbons, first catalyst and second catalyst to a catalyst separation system, the catalyst separation system configured to:

separate the first catalyst from a mixture comprising the second catalyst and the converted hydrocarbons based on at least one of catalyst size or catalyst density;

produce a first stream comprising separated first catalyst and a second stream comprising the second catalyst and the converted hydrocarbons; and

an inlet for receiving the first stream comprising the separated first catalyst thereby increasing a relative concentration of the first catalyst in the second reactor;

a disengagement vessel having one or more inlets for receiving (i) the second stream comprising the second catalyst and the converted hydrocarbons and (ii) the mixture of converted hydrocarbons and the catalyst mixture, the disengagement vessel configured to separate and recover a first effluent comprising converted hydrocarbons and a second effluent comprising a mixture of spent first and second catalyst; and

a flow line for conveying the mixture of spent first and second catalyst to the regenerator.

14. The process of claim 11, wherein the first two-reactor dual catalyst system comprises:

a first reactor for contacting the residue fluid catalytic cracking catalyst with a hydrocarbon feedstock to convert at least a portion of the hydrocarbon feedstock to lighter hydrocarbons;

a separator for separating the lighter hydrocarbons from spent residue fluid catalytic cracking catalyst;

a feed line for feeding separated spent cracking catalyst from the separator to a catalyst regenerator;

a catalyst transfer line for transferring a portion of the spent cracking catalyst from the catalyst regenerator to a contaminant removal vessel;

the contaminant removal vessel, for contacting the spent catalyst with a contaminant trapping additive having at least one of an average particle size or density greater than an average particle size or density of the residue fluid catalytic cracking catalyst;

a second separator for separating an overhead stream from the contaminant removal vessel into a first stream comprising residue fluid catalytic cracking catalyst and lifting gas and a second stream comprising contaminant trapping additive;

a recycle line for transferring contaminant trapping additive recovered in the second separator to the contaminant removal vessel;

a bottoms product line for recovering contaminant trapping additive from the contaminant removal vessel; and

a line for transferring the first stream to the catalyst regenerator.

15. The process of claim 11, wherein the common fractionation system separates the converted hydrocarbon fractions into three or more hydrocarbon fractions, the three or more hydrocarbon fractions including the one or more olefin fractions, the treated fluid catalytic cracking feedstock, and one or more of a C4 fraction, a C5 fraction, a FCC naphtha fraction, a heavy naphtha fraction, a light cycle oil fraction, or a slurry oil fraction.

16. The process of claim 15, further comprising feeding the C4 fraction and the FCC naphtha fraction to the second reactor, wherein the FCC naphtha fraction comprises one or more of a light naphtha fraction, a medium naphtha fraction, a heavy naphtha fraction, or a full range naphtha fraction.

17. The process of claim 15, further comprising feeding light cycle oil (LCO) or treated hydrocarbon liquid or slurry oil to either first or second reactor systems as a recycle feed or diluent.

18. The process of claim 15, further comprising feeding at least one of the C4 fraction and the C5 fraction to an olefins conversion unit and converting at least one of olefins or paraffins therein to at least one of ethylene or propylene.

19. The process of claim 15, further comprising feeding the medium or heavy naphtha fraction to an aromatics complex to reform the medium or heavy naphtha fraction and to recover one or more aromatics product streams.

20. The process of claim 11, further comprising separating the heavy boiling fraction into a medium boiling fraction and a residue fraction, wherein the residue fraction is fed as the heavy boiling fraction to the first two-reactor dual catalyst system, and wherein the medium boiling fraction is fed to the first reactor of the second two-reactor dual-catalyst system.

21. A system useful for catalytic cracking of a whole crude, the system comprising:

a separator for separating a whole crude into a light boiling fraction and a heavy boiling fraction;

a regenerator for regenerating spent first catalyst and spent second catalyst, and including a first outlet for conveying a mixture of regenerated first and second catalyst and a second outlet for conveying a mixture of regenerated first and second catalyst;

a riser reactor for contacting the heavy boiling fraction with a catalyst mixture, wherein the catalyst mixture comprises a first catalyst and a second catalyst, and wherein the first catalyst has a density greater than a density of the second catalyst, a particle size larger than a particle size of the second catalyst, or both a greater density and a larger particle size than the second catalyst, the riser reactor having:

an inlet for receiving the catalyst mixture comprising regenerated first and second catalyst from the regenerator; and

an outlet for conveying a mixture of converted hydrocarbons and the catalyst mixture;

a second reactor for contacting the light boiling fraction with a concentrated catalyst mixture comprising first catalyst and second catalyst, the second reactor having:

an inlet for receiving the catalyst mixture comprising regenerated first and second catalyst from the regenerator;

an outlet for conveying a mixture of converted hydrocarbons, first catalyst and second catalyst to a catalyst separation system, the catalyst separation system configured to:

separate the first catalyst from a mixture comprising the second catalyst and the converted hydrocarbons based on at least one of catalyst size or catalyst density, producing a first stream comprising separated first catalyst and a second stream comprising the second catalyst and the converted hydrocarbons;

an inlet for receiving the first stream comprising the separated first catalyst and for increasing a concentration of the first catalyst in the second reactor;

a disengagement vessel having one or more inlets for receiving (i) the second stream comprising the second catalyst and the converted hydrocarbons and (ii) the mixture of converted hydrocarbons and the catalyst mixture, the disengagement vessel configured to separate and recover a first effluent comprising converted hydrocarbons and a second effluent comprising a mixture of spent first and second catalyst; and

a flow line for conveying the mixture of spent first and second catalyst to the regenerator; and

wherein:

the system further comprises a fractionation system configured to receive the first effluent and to separate the converted hydrocarbons into three or more hydrocarbon fractions including a light hydrocarbon fraction, a naphtha fraction and a heavy fraction, and the fractionation system is further configured to recover a C5 fraction, the system further comprising an olefins conversion unit for converting olefins in the C5 fraction to at least one of ethylene or propylene, or

the fractionation system is further configured to recover a heavy naphtha fraction, the system further comprising an aromatics complex configured to reform the heavy naphtha fraction and recover one or more aromatics product streams.

22. The system of claim 21, wherein the separator comprises a hot oil processing system.

23. The system of claim 21, further comprising a flow line for feeding C4s and/or the naphtha fraction to the second reactor.

24. The system of claim 21, further comprising a flow line for feeding light cycle oil (LCO) or treated hydrocarbon liquid or slurry oil to either first or second reactor systems as a recycle feed or diluent.

25. The system of claim 21, further comprising a flow line for feeding the heavy fraction to the riser reactor.

26. The system of claim 22, wherein the separator for separating a whole crude into a light boiling fraction and a heavy boiling fraction is configured to separate a light boiling fraction having a 95% end boiling temperature in the range from about 300°C to about 420°C.