

Claims:

1. An integrated hydrotreating and steam pyrolysis process for the direct processing of a crude oil to produce olefinic and aromatic petrochemicals, the process comprising:
 - a. separating the crude oil into light components and heavy components;
 - b. charging the light components and hydrogen to a hydroprocessing zone operating under conditions effective to produce a hydroprocessed effluent reduced having a reduced content of contaminants, an increased paraffinicity, reduced Bureau of Mines Correlation Index, and an increased American Petroleum Institute gravity;
 - c. thermally cracking the hydroprocessed effluent in the presence of steam to produce a mixed product stream;
 - d. separating the thermally cracked mixed product stream;
 - e. purifying hydrogen recovered in step (d) and recycling it to step (b);
 - f. recovering olefins and aromatics from the separated mixed product stream; and
 - g. recovering a combined stream of pyrolysis fuel oil from the separated mixed product stream and heavy components from step (a) as a fuel oil blend.
2. The integrated process of claim 1, further comprising separating the hydroprocessing zone reactor effluents in a high pressure separator to recover
 - a gas portion that is cleaned and recycled to the hydroprocessing zone as an additional source of hydrogen, and
 - a liquid portion, and

separating the liquid portion from the high pressure separator in a low pressure separator into a gas portion and a liquid portion,

wherein the liquid portion from the low pressure separator is the hydroprocessed effluent subjected to thermal cracking and the gas portion from the low pressure separator is combined with the mixed product stream after the steam pyrolysis zone and before separation in step (d).

3. The integrated process of claim 1 wherein the thermal cracking step comprises heating hydroprocessed effluent in a convection section of a steam pyrolysis zone, separating the heated hydroprocessed effluent into a vapor fraction and a liquid fraction, passing the vapor fraction to a pyrolysis section of a steam pyrolysis zone, and discharging the liquid fraction.
4. The integrated process of claim 3 wherein the discharged liquid fraction is blended with pyrolysis fuel oil recovered in step (g).
5. The integrated process of claim 3 wherein separating the heated hydroprocessed effluent into a vapor fraction and a liquid fraction is with a vapor-liquid separation device based on physical and mechanical separation.
6. The integrated process of claim 5 wherein the vapor-liquid separation device includes a pre-rotational element having an entry portion and a transition portion, the entry portion having an inlet for receiving the flowing fluid mixture and a curvilinear conduit, a controlled cyclonic section having

an inlet adjoined to the pre-rotational element through convergence of the curvilinear conduit and the cyclonic section,

a riser section at an upper end of the cyclonic member through which vapors pass;

and

a liquid collector/settling section through which liquid passes

7. The integrated process of claim 1, wherein

step (d) comprises

compressing the thermally cracked mixed product stream with plural compression stages;

subjecting the compressed thermally cracked mixed product stream to caustic treatment to produce a thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

compressing the thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

dehydrating the compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

recovering hydrogen from the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide; and

obtaining olefins and aromatics as in step (e) and pyrolysis fuel oil as in step (f) from the remainder of the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

and

step (e) comprises purifying recovered hydrogen from the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide for recycle to the hydroprocessing zone.

8. The integrated process of claim 7, wherein recovering hydrogen from the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide further comprises separately recovering methane for use as fuel for burners and/or heaters in the thermal cracking step.

CLAIMS

1. An integrated hydrotreating and steam pyrolysis process for the direct processing of a crude oil to produce olefinic and aromatic petrochemicals, the process comprising:
 - a. separating the crude oil into light components and heavy components;
 - b. charging the light components and hydrogen to a hydroprocessing zone operating under conditions effective to produce a hydroprocessed effluent
 - c. thermally cracking hydroprocessed effluent in the presence of steam in a steam pyrolysis zone to produce a mixed product stream, wherein
 - the hydroprocessed effluent is heated in a convection section of the steam pyrolysis zone;
 - the heated hydroprocessed effluent is separated into a vapor phase and a liquid phase with a vapor-liquid separation device that includes
 - a pre-rotational element having an entry portion and a transition portion, the entry portion having an inlet for receiving a flowing fluid mixture and a curvilinear conduit,
 - a controlled cyclonic section having an inlet adjoined to the pre-rotational element through convergence of the curvilinear conduit and the cyclonic section and a riser section at an upper end of the cyclonic member through which the vapor phase passes, and
 - a liquid collector/settling section through which the liquid passes;
 - the vapor phase is passed to a pyrolysis section of the steam pyrolysis zone; and
 - the liquid phase is discharged;
 - d. separating the thermally cracked mixed product stream;

- e. purifying hydrogen recovered in step (d) and recycling it to step (b);
- f. recovering olefins and aromatics from the separated mixed product stream; and
- g. recovering pyrolysis fuel oil from the separated mixed product stream.

2. The integrated process of claim 1, further comprising

separating the hydroprocessing zone reactor effluents in a high pressure separator to recover

a gas portion that is cleaned and recycled to the hydroprocessing zone as an additional source of hydrogen, and

a liquid portion, and

separating the liquid portion from the high pressure separator in a low pressure separator into a gas portion and a liquid portion,

wherein the liquid portion from the low pressure separator is the hydroprocessed effluent subjected to thermal cracking and the gas portion from the low pressure separator is combined with the mixed product stream after the steam pyrolysis zone and before separation in step (d).

3. The integrated process of claim 1 wherein the discharged liquid fraction from step (c) is blended with pyrolysis fuel oil recovered in step (g).

4. The integrated process of claim 1, wherein

step (d) comprises

compressing the thermally cracked mixed product stream with plural compression stages;

subjecting the compressed thermally cracked mixed product stream to caustic treatment to produce a thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

compressing the thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

dehydrating the compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

recovering hydrogen from the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide; and

obtaining olefins and aromatics as in step (f) and pyrolysis fuel oil as in step (g) from the remainder of the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

and

step (e) comprises purifying recovered hydrogen from the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide for recycle to the hydroprocessing zone.

5. The integrated process of claim 4, wherein recovering hydrogen from the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide further comprises separately recovering methane for use as fuel for burners and/or heaters in the thermal cracking step.

6. The integrated process of claim 1, further comprising separating the hydroprocessed effluent into a heavy fraction and a light fraction in a hydroprocessed effluent separation zone, wherein the light fraction is the thermal cracking feed used in step (c), and blending the heavy fraction with the combined stream of step (g).

7. The integrated process of claim 6, wherein the hydroprocessed effluent separation zone is a flash separation apparatus.

8. The integrated process of claim 6, wherein the hydroprocessed effluent separation zone is a physical or mechanical apparatus for separation of vapors and liquids.

9. The integrated process of claim 1, further comprising separating the hydroprocessed effluent into a heavy fraction and a light fraction in a hydroprocessed effluent separation zone, wherein the light fraction is the thermal cracking feed used in step (c), wherein the hydroprocessed effluent separation zone comprises a flash vessel having at its inlet a vapor-liquid separation device including

a pre-rotational element having an entry portion and a transition portion, the entry portion having an inlet for receiving a flowing fluid mixture and a curvilinear conduit,

a controlled cyclonic section having an inlet adjoined to the pre-rotational element through convergence of the curvilinear conduit and the cyclonic section and a riser section at an upper end of the cyclonic member through which the light fraction passes, , and
a liquid outlet port through which the discharged heavy fraction passes.

10. The integrated process of claim 1, further comprising recovering a combined stream of pyrolysis fuel oil from the separated mixed product stream and heavy components from step (a) as a fuel oil blend.

11. An integrated hydrotreating and steam pyrolysis process for the direct processing of a crude oil to produce olefinic and aromatic petrochemicals, the process comprising:

- a. separating the crude oil into light components and heavy components;
- b. charging the light components and hydrogen to a hydroprocessing zone operating under conditions effective to produce a hydroprocessed effluent ;
- c. separating the hydroprocessed effluent into a discharged heavy fraction and a light fraction in a hydroprocessed effluent separation zone, wherein the hydroprocessed effluent

separation zone comprises a flash vessel having at its inlet a vapor-liquid separation device including

a pre-rotational element having an entry portion and a transition portion, the entry portion having an inlet for receiving a flowing fluid mixture and a curvilinear conduit,

a controlled cyclonic section having an inlet adjoined to the pre-rotational element through convergence of the curvilinear conduit and the cyclonic section and a riser section at an upper end of the cyclonic member through which the light fraction passes, and

a liquid outlet port through which the discharged heavy fraction passes;

d. thermally cracking the light fraction of the hydroprocessed effluent in the presence of steam to produce a mixed product stream;

e. separating the thermally cracked mixed product stream;

f. purifying hydrogen recovered in step (e) and recycling it to step (b);

g. recovering olefins and aromatics from the separated mixed product stream; and

h. recovering pyrolysis fuel oil from the separated mixed product stream.

12. The integrated process of claim 11, further comprising recovering a combined stream of pyrolysis fuel oil from the separated mixed product stream and heavy components from step (a) as a fuel oil blend.

13. The integrated process of claim 11, further comprising

separating the hydroprocessing zone reactor effluents in a high pressure separator to recover

a gas portion that is cleaned and recycled to the hydroprocessing zone as an additional source of hydrogen, and

a liquid portion, and

separating the liquid portion from the high pressure separator in a low pressure separator into a gas portion and a liquid portion,

wherein the liquid portion from the low pressure separator is the hydroprocessed effluent subjected to step (c) and the gas portion from the low pressure separator is combined with the mixed product stream after the steam pyrolysis zone and before separation in step (e).

14. The integrated process of claim 11 wherein the thermal cracking step comprises

heating the light fraction of the hydroprocessed effluent in a convection section of a steam pyrolysis zone,

separating the heated light fraction hydroprocessed effluent into a vapor fraction and a liquid fraction,

passing the vapor fraction to a pyrolysis section of a steam pyrolysis zone, and

discharging the liquid fraction.

15. The integrated process of claim 14 wherein the discharged liquid fraction is blended with pyrolysis fuel oil recovered in step (h).

16. The integrated process of claim 14 wherein separating the heated light fraction of the hydroprocessed effluent into a vapor fraction and a liquid fraction is with a vapor-liquid separation device based on physical and mechanical separation.

17. The integrated process of claim 16 wherein the vapor-liquid separation device includes

a pre-rotational element having an entry portion and a transition portion, the entry portion having an inlet for receiving a flowing fluid mixture and a curvilinear conduit,

a controlled cyclonic section having an inlet adjoined to the pre-rotational element through convergence of the curvilinear conduit and the cyclonic section and a riser section at an upper end of the cyclonic member through which vapors pass; and
a liquid collector/settling section through which liquid passes.

18. The integrated process of claim 11, wherein
step (e) comprises

compressing the thermally cracked mixed product stream with plural compression stages;

subjecting the compressed thermally cracked mixed product stream to caustic treatment to produce a thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

compressing the thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

dehydrating the compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

recovering hydrogen from the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide; and

obtaining olefins and aromatics as in step (f) and pyrolysis fuel oil as in step (g) from the remainder of the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide;

and

step (e) comprises purifying recovered hydrogen from the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide for recycle to the hydroprocessing zone.

19. The integrated process of claim 18, wherein recovering hydrogen from the dehydrated compressed thermally cracked mixed product stream with a reduced content of hydrogen sulfide and carbon dioxide further comprises separately recovering methane for use as fuel for burners and/or heaters in the thermal cracking step.

20. The integrated process of claim 11, further comprising blending the heavy fraction from the liquid outlet port with the pyrolysis fuel recovered in step (h).