

Claims:

1. An integrated hydrotreating, solvent deasphalting and steam pyrolysis process for the direct processing of a crude oil to produce olefinic and aromatic petrochemicals, the process comprising:
 - a. charging the crude oil 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;
 - b. charging the hydroprocessed effluent to a solvent deasphalting zone with an effective amount of solvent to produce a deasphalted and demetalized oil stream and a bottom asphalt phase;
 - c. thermally cracking the deasphalted and demetalized oil stream 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 (a);
 - 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, 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.

3. The integrated process of claim 2, 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.

4. The integrated process of claim 1 wherein the thermal cracking step comprises heating the deasphalted and demetalized oil stream in a convection section of a steam pyrolysis zone separating the heated deasphalted and demetalized oil 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.
5. The integrated process of claim 4 wherein the discharged liquid fraction is blended with pyrolysis fuel oil recovered in step (g).
6. The integrated process of claim 4 wherein separating the heated deasphalted and demetalized oil stream into a vapor fraction and a liquid fraction is with a vapor-liquid separation device based on physical and mechanical separation.
7. The integrated process of claim 6 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.

8. 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 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 (b) 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).

9. The integrated process of claim 1, wherein step (b) comprises

mixing the crude oil feedstock with make-up solvent and optionally fresh solvent;

transferring the mixture to a primary settler in which a primary deasphalted and demetalized oil phase and a primary asphalt phase are formed;

transferring the primary deasphalted and demetalized oil phase to a secondary settler in which a secondary deasphalted and demetalized oil phase and a secondary asphalt phase are formed;

recycling the secondary asphalt phase to the primary settler to recover additional deasphalted and demetalized oil;

conveying the secondary deasphalted and demetalized oil phase to a deasphalted and demetalized oil separation zone to obtain a recycle solvent stream and a substantially solvent-free deasphalted and demetalized oil stream;

conveying the primary asphalt phase is conveyed to a separator vessel for flash separation of an additional recycle solvent stream and a bottom asphalt phase,

wherein the substantially solvent-free deasphalted and demetalized oil stream is the feed to the steam pyrolysis zone.

10. The integrated process as in claim 9, wherein the bottom asphalt phase is blended with pyrolysis fuel oil recovered in step (g).

CLAIMS

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

a. charging the crude oil to a hydroprocessing zone operating under conditions effective to produce a hydroprocessed effluent having a reduced content of contaminants, an increased paraffinicity, reduced Bureau of Mines Correlation Index, and an increased American Petroleum Institute gravity;

b. charging the hydroprocessed effluent to a solvent deasphalting zone with an effective amount of solvent to produce a deasphalted and demetalized oil stream and a bottom asphalt phase;

c. thermally cracking the deasphalted and demetalized oil stream in the presence of steam in a steam pyrolysis zone to produce a mixed product stream, wherein

the deasphalted and demetalized oil stream is heated in a convection section of the steam pyrolysis zone;

the heated deasphalted and demetalized oil stream 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 (a);
- 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, 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.

3. The integrated process of claim 2, 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.

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

5. The integrated process of claim 1, further comprising separating the deasphalted and demetalized oil from the solvent deasphalting zone into a heavy fraction and a light fraction in a deasphalted and demetalized oil separation zone, wherein the light fraction is the thermal cracking feed used in step(c), and blending the heavy fraction with pyrolysis fuel oil recovered in step (g).

6. The integrated process of claim 5, wherein the deasphalted and demetalized oil separation zone is a flash separation apparatus.

7. The integrated process of claim 5, wherein the deasphalted and demetalized oil separation zone is a physical or mechanical apparatus for separation of vapors and liquids.

8. 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 step (b) 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).

9. The integrated process of claim 1, wherein step (b) comprises
mixing the crude oil feedstock with make-up solvent and optionally fresh solvent;
transferring the mixture to a primary settler in which a primary deasphalted and demetalized oil phase and a primary asphalt phase are formed;

transferring the primary deasphalted and demetalized oil phase to a secondary settler in which a secondary deasphalted and demetalized oil phase and a secondary asphalt phase are formed;

recycling the secondary asphalt phase to the primary settler to recover additional deasphalted and demetalized oil;

conveying the secondary deasphalted and demetalized oil phase to a deasphalted and demetalized oil separation zone to obtain a recycle solvent stream and a substantially solvent-free deasphalted and demetalized oil stream; and

conveying the primary asphalt phase to a separator vessel for flash separation of an additional recycle solvent stream and a bottom asphalt phase,

wherein the substantially solvent-free deasphalted and demetalized oil stream is the feed to the steam pyrolysis zone.

10. The integrated process as in claim 9, wherein the bottom asphalt phase is blended with pyrolysis fuel oil recovered in step (g).