

RESIDUE HYDROCRACKING

FIELD OF THE DISCLOSURE

[0001] Embodiments disclosed herein relate generally to processes for hydrocracking residue and other heavy hydrocarbon fractions. More specifically, embodiments disclosed herein relate to processes for cracking residue and other heavy hydrocarbon fractions while simultaneously reducing asphaltenic sediment formation downstream of ebullated bed reactor systems and improving the quality of the conversion products.

BACKGROUND

[0002] Attempts to mitigate sediment deposition problems in equipment downstream of ebullated bed reactors, such as separators, exchangers, heaters, and fractionation equipment have used various chemical and mechanical means. However, sediment deposition remains a challenge. Precipitation of asphaltenic material (“sediment”) is a major issue in most, if not all, high conversion residue hydrocracking units, especially those utilizing ebullated bed hydrocracking, and often limits the extent of conversion and reduces the on stream factor of many units. Additionally, products from ebullated bed hydrocracking are typically of lower quality, as a significant portion of the conversion occurs as a result of thermal cracking and a contribution of catalytic hydroconversion that improves product quality is somewhat limited.

SUMMARY OF THE CLAIMED EMBODIMENTS

[0003] In one aspect, embodiments disclosed herein relate to a process for upgrading residuum hydrocarbons and decreasing tendency of the resulting products toward asphaltenic sediment formation in downstream processes. The process includes: a) contacting a residuum hydrocarbon fraction and hydrogen with a hydroconversion catalyst in a hydrocracking reaction zone to convert at least a portion of the residuum hydrocarbon fraction to lighter hydrocarbons; b) recovering an effluent from the hydrocracking reaction zone; c) contacting hydrogen and at least a portion of the effluent with a resid hydrotreating catalyst; and d) separating the effluent to recover two or more hydrocarbon fractions, wherein steps (c) and (d) are performed concurrently in a reactor / stripper having the resid hydrotreating catalyst contained in a lower portion of the reactor / stripper, and wherein the reactor / stripper further comprises a distillate hydrotreating catalyst contained in an upper portion of the reactor / stripper, and wherein step (c) is also performed in an upflow reactor located upstream of the reactor/stripper.

[0004] In another aspect, embodiments disclosed herein relate to a system for upgrading residuum hydrocarbons and decreasing tendency of the resulting products

toward asphaltenic sediment formation in downstream processes. The system includes: a) a hydrocracking reaction zone for contacting a residuum hydrocarbon fraction and hydrogen with a hydroconversion catalyst to convert at least a portion of the residuum hydrocarbon fraction to lighter hydrocarbons and recovering a hydrocracked effluent; b) a reactor for contacting hydrogen and at least a portion of the hydrocracked effluent with a resid hydrotreating catalyst; and c) a separation system for separating the effluent to recover two or more hydrocarbon fractions, wherein reactor (b) and separation system (c) comprise a reactor / stripper containing a resid hydrotreating catalyst in a lower portion of the reactor / stripper for concurrently contacting hydrogen and at least a portion of the hydrocracked effluent with a resid hydrotreating catalyst and separating the effluent to recover two or more hydrocarbon fractions; and wherein the reactor / stripper further comprises a distillate hydrotreating catalyst contained in an upper portion of the reactor / stripper; and an upflow reactor upstream of the reactor / stripper for contacting hydrogen and the hydrocracked effluent with a first resid hydrotreating catalyst.

[0005] In another aspect, embodiments disclosed herein relate to a process for upgrading residuum hydrocarbons and decreasing tendency of the resulting products toward asphaltenic sediment formation in downstream processes. The process includes: a) contacting a residuum hydrocarbon fraction and hydrogen with a first hydroconversion catalyst in a first hydrocracking reaction zone to convert at least a portion of the residuum hydrocarbon fraction to lighter hydrocarbons and recover a first hydrocracked effluent; b) quenching the first hydrocracked effluent with at least one of an aromatic diluent and a hydrogen-containing gas stream; c) separating the quenched first hydrocracked effluent to recover a first overheads vapor fraction comprising distillate hydrocarbons and a first bottoms liquid fraction; d) contacting hydrogen and the first bottoms liquid fraction with a second hydroconversion catalyst, which may be the same or different than the first hydroconversion catalyst, in a second hydrocracking reaction zone to convert at least a portion of the first bottoms liquid fraction to lighter hydrocarbons and recover a second hydrocracked effluent; e) contacting hydrogen and at least a portion of the second hydrocracked effluent with a first resid hydrotreating catalyst to form a hydrotreated product; f) separating the hydrotreated product to recover two or more hydrocarbon fractions, wherein the contacting (e) and separating (f) are performed concurrently in a reactor / stripper having the first resid hydrotreating catalyst contained in a lower portion of the reactor / stripper, and wherein the reactor / stripper further comprises a distillate hydrotreating catalyst contained in an upper portion of the reactor / stripper, and wherein step (e) is also performed in an upflow reactor located upstream of the reactor/stripper.

CLAIMS

What is claimed:

1. A process for upgrading residuum hydrocarbons and decreasing tendency of the resulting products toward asphaltenic sediment formation in downstream processes, the process comprising:
 - a) contacting a residuum hydrocarbon fraction and hydrogen with a hydroconversion catalyst in a hydrocracking reaction zone to convert at least a portion of the residuum hydrocarbon fraction to lighter hydrocarbons;
 - b) recovering an effluent from the hydrocracking reaction zone;
 - c) contacting hydrogen and at least a portion of the effluent with a resid hydrotreating catalyst;
 - d) separating the effluent to recover two or more hydrocarbon fractionswherein steps (c) and (d) are performed concurrently in a reactor / stripper having the resid hydrotreating catalyst contained in a lower portion of the reactor / stripper, ~~and~~
wherein the reactor / stripper further comprises a distillate hydrotreating catalyst contained in an upper portion of the reactor / stripper, and wherein step (c) is also performed in an upflow reactor located upstream of the reactor/stripper.
- ~~2. The process of claim 1, wherein step (c) is also performed in an upflow reactor located upstream of the reactor/stripper.~~
- ~~3.2.~~ The process of claim 1, wherein the contacting (c) and separating (d) further comprise:
 - contacting hydrogen and the effluent with a first resid hydrotreating catalyst in an upflow reactor located upstream of the reactor/stripper;
 - recovering an effluent from the upflow reactor;
 - feeding the effluent from the upflow reactor to the reactor / stripper to concurrently:
 - separate the effluent to recover two or more hydrocarbon fractions comprising at least a heavy hydrocarbon fraction and a light hydrocarbon fraction;
 - contact hydrogen and the heavy hydrocarbon fraction with a second resid hydrotreating catalyst contained in a lower portion of the reactor / stripper;
 - and

contact hydrogen and the light hydrocarbon fraction with a distillate hydrotreating catalyst contained in an upper portion of the reactor / stripper.

~~4.3.~~ The process of claim 1, wherein the hydrocracking reaction zone comprises one or more ebullated bed reactors, where multiple reactors may be contained in series, parallel, or a combination thereof.

~~5.4.~~ The process of claim ~~43~~, further comprising operating the one or more ebullated bed reactors at a hydrogen partial pressures of 70 to 170 bara, temperatures of 380°C to 450°C, and a LHSV of 0.15 to 2.0 h⁻¹.

~~6.5.~~ The process of claim 1, further comprising quenching the effluent recovered from the hydrocracking reaction zone with at least one of an aromatic diluent and a hydrogen-containing gas stream.

~~7.6.~~ A system for upgrading residuum hydrocarbons and decreasing tendency of the resulting products toward asphaltenic sediment formation in downstream processes, the system comprising:

- a) a hydrocracking reaction zone for contacting a residuum hydrocarbon fraction and hydrogen with a hydroconversion catalyst to convert at least a portion of the residuum hydrocarbon fraction to lighter hydrocarbons and recovering a hydrocracked effluent;
- b) a reactor for contacting hydrogen and at least a portion of the hydrocracked effluent with a resid hydrotreating catalyst;
- c) a separation system for separating the effluent to recover two or more hydrocarbon fractions

wherein reactor (b) and separation system (c) comprise a reactor / stripper containing a resid hydrotreating catalyst in a lower portion of the reactor / stripper for concurrently contacting hydrogen and at least a portion of the hydrocracked effluent with a resid hydrotreating catalyst and separating the effluent to recover two or more hydrocarbon fractions; and

wherein the reactor / stripper further comprises a distillate hydrotreating catalyst contained in an upper portion of the reactor / stripper; and

an upflow reactor upstream of the reactor / stripper for contacting hydrogen and the hydrocracked effluent with a first resid hydrotreating catalyst.

~~8.7.~~ The system of claim ~~76~~, wherein the reactor (b) and separation system (c) comprise:

~~an upflow reactor for contacting hydrogen and the hydrocracked effluent with a first
resid hydrotreating catalyst;~~

a flow conduit for recovering an effluent from the upflow reactor;

the reactor / stripper for concurrently:

separating the effluent from the upflow reactor to recover two or more
hydrocarbon fractions comprising at least a heavy hydrocarbon fraction
and a light hydrocarbon fraction;

contacting hydrogen and the heavy hydrocarbon fraction with a second resid
hydrotreating catalyst contained in a lower portion of the reactor / stripper;
and

contacting hydrogen and the light hydrocarbon fraction with the distillate
hydrotreating catalyst contained in the upper portion of the reactor /
stripper.

~~9.8.~~ The system of claim ~~76~~, wherein the hydrocracking reaction zone comprises one or more
ebullated bed reactors, where multiple reactors may be oriented in series, parallel, or a
combination thereof.

~~10.9.~~ The system of claim ~~76~~, further comprising a flow conduit for quenching the
hydrocracked effluent recovered from the hydrocracking reaction zone with at least one of an
aromatic diluent and a hydrogen-containing gas stream.

~~11.10.~~ A process for upgrading residuum hydrocarbons and decreasing tendency of the
resulting products toward asphaltenic sediment formation in downstream processes, the
process comprising:

- a) contacting a residuum hydrocarbon fraction and hydrogen with a first
hydroconversion catalyst in a first hydrocracking reaction zone to convert at least a
portion of the residuum hydrocarbon fraction to lighter hydrocarbons and recover a
first hydrocracked effluent;
- b) quenching the first hydrocracked effluent with at least one of an aromatic diluent and
a hydrogen-containing gas stream;
- c) separating the quenched first hydrocracked effluent to recover a first overheads vapor
fraction comprising distillate hydrocarbons and a first bottoms liquid fraction;

d) contacting hydrogen and the first bottoms liquid fraction with a second hydroconversion catalyst, which may be the same or different than the first hydroconversion catalyst, in a second hydrocracking reaction zone to convert at least a portion of the first bottoms liquid fraction to lighter hydrocarbons and recover a second hydrocracked effluent;

e) contacting hydrogen and at least a portion of the second hydrocracked effluent with a first resid hydrotreating catalyst to form a hydrotreated product;

f) separating the hydrotreated product to recover two or more hydrocarbon fractions;

wherein the contacting (e) and separating (f) are performed concurrently in a reactor / stripper having the first resid hydrotreating catalyst contained in a lower portion of the reactor / stripper, and

wherein the reactor / stripper further comprises a distillate hydrotreating catalyst contained in an upper portion of the reactor / stripper, and

wherein step (e) is also performed in an upflow reactor located upstream of the reactor/stripper.

~~12.11.~~ The process of claim ~~11~~10, further comprising contacting at least a portion of the quenched first hydrocracked effluent with a second resid hydrotreating catalyst to form a second hydrotreated product, wherein the contacting is performed prior to, concurrent with, or both prior to and concurrent with separating step (c).

~~13.12.~~ The process of claim ~~12~~11, wherein the contacting and separating (c) are performed concurrently, the separating and contacting further comprising contacting at least a portion of the quenched first hydrocracked effluent with the distillate hydrotreating catalyst.

~~14.~~ The process of claim ~~11~~, wherein ~~step (e) is also performed in an upflow reactor located upstream of the reactor/stripper.~~

~~15.13.~~ The process of claim ~~14~~10, wherein the contacting (e) and separating (f) further comprise:

contacting hydrogen and the second hydrocracked effluent with the first resid hydrotreating catalyst in an upflow reactor located upstream of the reactor/stripper;

recovering an effluent from the upflow reactor;

feeding the effluent from the upflow reactor to the reactor / stripper to concurrently:

separate the effluent to recover two or more hydrocarbon fractions comprising at least a heavy hydrocarbon fraction and a light hydrocarbon fraction;

contact hydrogen and the heavy hydrocarbon fraction with a second resid
hydrotreating catalyst contained in a lower portion of the reactor / stripper;
and
contact hydrogen and the light hydrocarbon fraction with the distillate
hydrotreating catalyst contained in the upper portion of the reactor /
stripper.

~~16~~.14. The process of claim ~~11~~10, wherein the first and second hydrocracking reaction zones
each comprise one or more ebullated bed reactors, where multiple reactors may be oriented in
series, parallel, or a combination thereof.

~~17~~.15. The process of claim ~~16~~14, further comprising operating the one or more ebullated
bed reactors in each zone at a hydrogen partial pressures of 70 to 170 bara, temperatures of
380°C to 450°C, and a LHSV of 0.25 to 2.0 h⁻¹.

~~18~~.16. The process of claim ~~16~~14, wherein the first and second hydrocracking reaction zones
are operated at an overall residue conversion in the range from about 50 wt% to about 85
wt%.