

## CLAIMS

What is claimed:

1. A process for upgrading resid, comprising:

feeding hydrogen and a resid hydrocarbon to a first ebullated bed reactor containing a first hydrocracking catalyst;  
contacting the resid and hydrogen in the presence of the hydrocracking catalyst at conditions of temperature and pressure to crack at least a portion of the resid;  
separating a product from the first reactor into a first gas phase and a first liquid phase product;  
feeding hydrogen and a deasphalted oil hydrocarbon fraction and a vacuum distillate hydrocarbon fraction to a second ebullated bed reactor containing a hydrotreating catalyst;  
contacting the deasphalted oil hydrocarbon fraction, the vacuum distillate hydrocarbon fraction and hydrogen in the presence of the hydrotreating catalyst at conditions of temperature and pressure to hydrotreat at least a portion of the deasphalted oil hydrocarbon fraction and the vacuum distillate hydrocarbon fraction;  
separating a product from the second reactor into a second gas phase and a second liquid phase product;  
separating the second liquid phase product into a second reactor effluent and a residual fluid catalytic cracking (RFCC) feed;  
fractionating the first liquid phase product and the second reactor effluent to form at least one distillate hydrocarbon fraction, the vacuum distillate hydrocarbon fraction, and at least one resid hydrocarbon fraction; and  
feeding the at least one resid hydrocarbon fraction to a solvent deasphalting unit to provide an asphaltene fraction and the deasphalted oil hydrocarbon fraction.

2. The process of claim 1, wherein the fractionating comprises:

separating the first liquid phase product and the second reactor effluent in an atmospheric distillation tower to recover a fraction comprising hydrocarbons boiling in a range of atmospheric distillates and a first bottoms fraction comprising hydrocarbons having a normal boiling point of at least 340°C;

separating the first bottoms fraction in a vacuum distillation tower to recover a fraction comprising hydrocarbons boiling in a range of vacuum distillates and a second bottoms fraction comprising hydrocarbons having a boiling temperature of at least 480°C;

feeding the second bottoms fraction to the solvent deasphalting unit as the resid hydrocarbon fraction.

3. The process of claim 2, further comprising  
cooling the first gas phase and the second gas phase to recover a hydrogen-containing gas fraction and a distillate fraction; and  
feeding the distillate fraction to the first liquid phase product and the second reactor effluent.
4. The process of claim 3, further comprising recycling at least a portion of the recovered hydrogen to at least one of the first reactor and the second reactor.
5. The process of claim 2, further comprising cooling the second bottoms fraction via direct heat exchange with at least one of a portion of the resid and a portion of the first bottoms fraction.
6. The process of claim 1, wherein:
  - (a) at least one of an operating temperature and an operating pressure in the second reactor is less than an operating temperature and an operating pressure of the first reactor; or
  - (b) the at least one resid hydrocarbon fraction comprises hydrocarbons with a normal boiling point of at least 480°C.
7. A process for upgrading resid in a system comprising:
  - a first ebullated bed reactor;
  - a first separator;
  - a stripping tower;
  - a fractionation system; and
  - a solvent deasphalting system;the process comprising:
  - operating the system in a first mode to produce a feed for a residual fluid catalytic cracking (RFCC) unit, the first mode comprising:
    - reacting a deasphalted oil and a vacuum distillate in the first ebullated bed reactor containing a hydrotreating catalyst to form a first effluent;

separating the first effluent in the first separator into a first gas phase and a first liquid phase;  
 stripping the first liquid phase in the stripping tower to produce a strippers bottom and a stripper overhead;  
 fractionating the stripper overhead in the fractionation system to produce at least one atmospheric distillate and an atmospheric bottoms;  
 fractionating the atmospheric bottoms in the fractionation system to produce the vacuum distillate and a vacuum bottoms;  
 solvent deasphalting the vacuum bottoms in the solvent deasphalting system to produce the deasphalted oil; and  
 transporting the strippers bottoms as the feed to the RFCC unit;  
 operating the system in a second mode to maximize the resid conversion in the first ebullated bed reactor, the second mode comprising:  
 reacting the deasphalted oil in the first ebullated bed reactor containing a hydrocracking catalyst to form a second effluent;  
 separating the second effluent in the first separator into a second gas phase and a second liquid phase;  
 fractionating the second liquid phase in the fractionation system to produce at least one atmospheric distillate and an atmospheric bottoms;  
 fractionating the atmospheric bottoms in the fractionation system to produce the vacuum distillate and the vacuum bottoms; and  
 solvent deasphalting the vacuum bottoms to produce the deasphalted oil;  
 transitioning the system between the first mode and the second mode, wherein the transitioning comprises:  
 removing the hydrotreating catalyst from the first ebullated bed reactor while simultaneously adding a hydrocracking catalyst to the first ebullated bed reactor;  
 fractionating the first liquid phase in the fractionation system to produce the at least one atmospheric distillate and the atmospheric bottoms.

8. The process of claim 7, wherein the system further comprises:

a second ebullated bed reactor; and

a second separator;

the second mode further comprises:

reacting a resid hydrocarbon in the second ebullated bed reactor containing a hydrocracking catalyst to form a third effluent;  
separating the third effluent in the second separator into a third gas phase and a third liquid phase; and  
fractionating the third liquid phase in the fractionation system to produce the at least one atmospheric distillate and the atmospheric bottoms.

9. The process of claim 7, further comprising transitioning the system between the second mode back to the first mode.

10. The process of claim 7, wherein:

(a) transitioning further comprises lowering the temperature of the first ebullated bed reactor;  
or

(b) removing the hydrotreating catalyst from the first ebullated bed reactor comprises increasing a speed of an ebullating pump.

11. A system for upgrading residuum hydrocarbons, the system comprising:

a first ebullated bed hydroconversion reactor system for contacting the residuum hydrocarbons and hydrogen with a first hydroconversion catalyst to produce a first effluent;

a first mass transfer device to separate the first effluent into a first gas phase and a first liquid phase;

a second ebullated bed hydroconversion reactor system configured to operate in residual fluid catalytic cracking (RFCC) unit feed mode by contacting a vacuum distillate stream, a deasphalted gas oil stream, and hydrogen with a hydrotreatment catalyst to produce a second effluent;

a second mass transfer device to separate the second effluent into a second gas phase and a second liquid phase;

a third mass transfer device to separate the second liquid phase into the RFCC unit feed and an overheads;

an atmospheric fractionation unit to fractionate the first liquid phase and the overheads to recover a hydrocarbon atmospheric distillate stream and a hydrocarbon atmospheric residuum stream;

a vacuum fractionation unit to fractionate the hydrocarbon atmospheric residuum stream to recover the vacuum distillate stream and a first residuum stream; and

a solvent deasphalting unit for recovering the deasphalted gas oil stream and an asphaltenes stream from the first residuum stream.

12. The system of claim 11, wherein one or more of the following apply:

- (a) the system further comprising a first gasification system for converting the asphaltenes stream to a synthesis gas;
- (b) the system further comprising a second gasification system for converting the first gas phase and the second gas phase to a distillates stream to be fed to the atmospheric fractionation unit and the hydrogen to be fed to the first ebullated bed hydroconversion reactor system and the second ebullated bed hydroconversion reactor system;
- (c) the third mass transfer device comprises a stripping tower;
- (d) the first mass transfer device comprises a high temperature/high pressure separator;
- (e) the second mass transfer device comprises a high temperature/high pressure separator; and
- (f) the second ebullated bed hydroconversion reactor system is configured to alternate operation between a maximize residuum hydrocarbons conversion mode or the RFCC unit feed mode, optionally wherein the second gasification system comprises a compressor.

13. A process for upgrading resid, comprising:

- feeding hydrogen and a resid hydrocarbon to a first reactor containing a first hydrocracking catalyst;
- contacting the resid and hydrogen in the presence of the hydrocracking catalyst at conditions of temperature and pressure to crack at least a portion of the resid;
- separating a product from the first reactor into a first gas phase and a first liquid phase product;
- feeding hydrogen and a deasphalted oil hydrocarbon fraction and a vacuum distillate hydrocarbon fraction to a second reactor containing a hydrotreating catalyst, wherein the second reactor is a fixed bed reactor;
- contacting the deasphalted oil hydrocarbon fraction, the vacuum distillate hydrocarbon fraction and hydrogen in the presence of the hydrotreating catalyst at conditions of temperature and pressure to hydrotreat at least a portion of the deasphalted oil hydrocarbon fraction and the vacuum distillate hydrocarbon fraction;
- separating a product from the second reactor into a second gas phase and a second liquid phase product;

- separating the second liquid phase product into a second reactor effluent and a residual fluid catalytic cracking (RFCC) feed;
- fractionating the first liquid phase product and the second reactor effluent to form at least one distillate hydrocarbon fraction, the vacuum distillate hydrocarbon fraction, and at least one resid hydrocarbon fraction; and
- feeding the at least one resid hydrocarbon fraction to a solvent deasphalting unit to provide an asphaltene fraction and the deasphalted oil hydrocarbon fraction.
14. The process of claim 13, wherein the fractionating comprises:
- separating the first liquid phase product and the second reactor effluent in an atmospheric distillation tower to recover a fraction comprising hydrocarbons boiling in a range of atmospheric distillates and a first bottoms fraction comprising hydrocarbons having a normal boiling point of at least 340°C;
- separating the first bottoms fraction in a vacuum distillation tower to recover a fraction comprising hydrocarbons boiling in a range of vacuum distillates and a second bottoms fraction comprising hydrocarbons having a boiling temperature of at least 480°C;
- feeding the second bottoms fraction to the solvent deasphalting unit as the resid hydrocarbon fraction.
15. The process of claim 14, further comprising
- cooling the first gas phase and the second gas phase to recover a hydrogen-containing gas fraction and a distillate fraction; and
- feeding the distillate fraction to the first liquid phase product and the second reactor effluent.
16. The process of claim 15, further comprising recycling at least a portion of the recovered hydrogen to at least one of the first reactor and the second reactor.
17. The process of claim 14, further comprising cooling the second bottoms fraction via direct heat exchange with at least one of a portion of the resid and a portion of the first bottoms fraction.
18. The process of claim 13, wherein:
- (a) at least one of an operating temperature and an operating pressure in the second reactor is less than an operating temperature and an operating pressure of the first reactor; or
- (b) the at least one resid hydrocarbon fraction comprises hydrocarbons with a normal boiling point of at least 480°C.

19. A system for upgrading residuum hydrocarbons, the system comprising:

- an ebullated bed hydroconversion reactor system for contacting the residuum hydrocarbons and hydrogen with a first hydroconversion catalyst to produce a first effluent;
- a first mass transfer device to separate the first effluent into a first gas phase and a first liquid phase;
- a fixed bed hydroconversion reactor system configured to operate in residual fluid catalytic cracking (RFCC) unit feed mode by contacting a vacuum distillate stream, a deasphalted gas oil stream, and hydrogen with a hydrotreatment catalyst to produce a second effluent;
- a second mass transfer device to separate the second effluent into a second gas phase and a second liquid phase;
- a third mass transfer device to separate the second liquid phase into the RFCC unit feed and an overheads;
- an atmospheric fractionation unit to fractionate the first liquid phase and the overheads to recover a hydrocarbon atmospheric distillate stream and a hydrocarbon atmospheric residuum stream;
- a vacuum fractionation unit to fractionate the hydrocarbon atmospheric residuum stream to recover the vacuum distillate stream and a first residuum stream; and
- a solvent deasphalting unit for recovering the deasphalted gas oil stream and an asphaltenes stream from the first residuum stream.

20. The system of claim 19, wherein one or more of the follow apply:

- (a) the system further comprising a first gasification system for converting the asphaltenes stream to a synthesis gas;
- (b) the system further comprising a second gasification system for converting the first gas phase and the second gas phase to a distillates stream to be fed to the atmospheric fractionation unit and the hydrogen to be fed to the first ebullated bed hydroconversion reactor system and the second ebullated bed hydroconversion reactor system;
- (c) the third mass transfer device comprises a stripping tower;
- (d) the first mass transfer device comprises a high temperature/high pressure separator;
- (e) the second mass transfer device comprises a high temperature/high pressure separator; and

(f) the second ebullated bed hydroconversion reactor system is configured to alternate operation between a maximize residuum hydrocarbons conversion mode or the RFCC unit feed mode, optionally wherein the second gasification system comprises a compressor.