Claims

1. A process for converting inferior feedstock oil, comprising:

a) feeding an inferior feedstock oil into a hydrogenation reactor to conduct a hydrogenation reaction, separating an effluent from the hydrogenation reactor to obtain a hydrogenated gas, a hydrogenated naphtha, a hydrogenated diesel, and a hydrogenated residual oil,

wherein, in the hydrogenation reactor, based on the inferior feedstock oil, a yield of the hydrogenated residual oil is 85%-95% by weight;

b) feeding the hydrogenated residual oil obtained in step a) to a first catalytic cracking reactor, separating an effluent from the first catalytic cracking reactor to obtain a first dry gas, a first LPG, a first gasoline, a first diesel, and a first FCC-gas oil;

c) feeding the first FCC-gas oil obtained in step b) to a gas oil hydrogenation reactor, separating an effluent from the gas oil hydrogenation reactor to obtain a hydrogenated gas oil;

d) feeding the hydrogenated gas oil obtained in step c) to the first catalytic cracking reactor or a second catalytic cracking reactor; and

e) monitoring a density or a carbon residue content of the hydrogenated residual oil and increasing a reaction severity of the hydrogenation reaction when the density, the carbon residue content, or both, increases,

wherein the hydrogenation of the inferior feedstock oil in step a) is carried out with a variation percent of sulfur removal rate of less than 40%, a variation percent of metal removal rate of less than 20%, a variation percent of nitrogen removal rate of less than 40%, and/or a variation percent of carbon residue removal rate of less than 40% for at 8000 hrs on stream time, and

wherein the hydrogenation of the FCC-gas oil in step b) is carried out in presence of a hydrogenation catalyst comprising 5-20 wt% of hydrogenation protecting catalyst, 5-35 wt%

hydrodemetallization and hydrodesulfurization catalyst, and 55-85 wt% hydrotreatment catalyst.

2. The process according to claim 1, wherein the process further comprises step e) obtaining a second FCC-gas oil from the second catalytic cracking reactor; and step d) feeding the second FCC-gas oil to the gas oil hydrogenation reactor.

3. The process according to claim 1, wherein when the density of the hydrogenated residual oil increases by 0.001-0.005 g/cm^3, or the carbon residue content of the hydrogenated residual oil increases by 0.1%-0.5%, increasing the reaction severity in the hydrogenation reaction.

4. The process according to claim 1, when a density of the hydrogenated residual oil increases by more than 0.005 g/cm^3 every 1000 hrs, and/or when a carbon residue content of the hydrogenated residual oil increases by more than 0.5 wt% every 1000 hrs, increasing the reaction severity in the hydrogenation reactor.

5. The process according to claim 1, wherein the inferior feedstock oil is a petroleum hydrocarbon, a mineral oil, or a mixture thereof, wherein the petroleum hydrocarbon is selected from the group consisting of atmospheric gas oil, vacuum gas oil, atmospheric residual oil, vacuum residual oil, hydrogenated residual oil, coker gas oil, deasphalted oil, and mixtures thereof, and the mineral oil is selected from the group consisting of liquefied oil derived from coal or natural gas, tar sand oil, tight oil, shale oil, and mixtures thereof.

6. The process according to claim 1, wherein the inferior feedstock oil has a density at 20 °C of 980-1000 kg/m^3, a weight percent of carbon residue of 10-15 wt%, and/or a content of metals (Ni+V) of 60-600 ppm.

7. The process according to claim 1, wherein step b) further comprising:

(1) subjecting the hydrogenated residual oil to a first cracking reaction by contacting the hydrogenated residual oil and a first regenerated catalytic cracking catalyst in a lower reaction zone in the first catalytic cracking reactor to obtain a first cracking product and a first semi-regenerated catalytic cracking catalyst; and

(2) subjecting the first cracking product and the first semi-regenerated catalytic cracking catalyst obtained in step (1) to a first further catalytic conversion reaction in an upper reaction zone of the first catalytic cracking reactor to produce the effluent from the first catalytic reactor.

8. The process according to claim 7, wherein the first cracking reaction in the lower reaction zone has a reaction temperature of 530-620 °C, a weight hourly space velocity of 30-180 h^{-1}, a catalyst/oil ratio of 4-12, a steam/oil ratio of 0.03-0.3, and a reaction pressure of 130 kPa-450 kPa; and wherein the first further catalytic conversion reaction in the upper reaction zone has a reaction temperature of 460 °C-520 °C, a weight hourly space velocity of 20-100 h^{-1}, a catalyst/oil ratio of 3-15, a steam/oil ratio of 0.03-0.3, and a reaction pressure of 130 kPa-450 kPa.

9. The process according to claim 1, wherein a hydrogen content of the first FCC-gas oil is 10.5-15 wt% and, based on the hydrogenated residual oil, a yield of the first FCC-gas oil is 15%-50% by weight.

10. The process according to claim 1, further comprising feeding a second-processed gas oil to the gas oil hydrogenation reactor, and the second-processed gas oil is selected from the group consisting of coker gas oil, deasphalted oil, FCC-gas oil produced by other FCC units, and combinations thereof.

11. The process according to claim 1, wherein the gas oil hydrogenation reactor is a fixed bed reactor containing a hydrogenation catalyst.

12. The process according to claim 1, wherein the gas oil hydrogenation reactor has a reaction pressure of 5.0-20.0 MPa, a reaction temperature of 300-430 ℃, a liquid hourly space velocity of 0.2-5.0 h^{-1}, and a hydrogen/oil volume ratio of 200-1800 normal m^3/m^3.

13. The process according to claim 1, wherein the second catalytic cracking reactor has a reaction temperature of 450 ℃-620 ℃, a weight hourly space velocity of 1-100 h^{-1}, a catalyst/oil ratio of 1-25, and a steam/oil ratio of 0.03-0.3.

14. The process according to claim 1, wherein, in the second catalytic cracking reactor, the hydrogenated gas oil and a second regenerated catalytic cracking catalyst are subjected to a second cracking reaction in a lower zone of the second catalytic cracking reactor to obtain a second cracking product and a second semi-regenerated catalytic cracking catalyst; and
the second cracking product and the second semi-regenerated catalytic cracking catalyst are then subjected to a second further catalytic conversion reaction in an upper reaction zone of the second catalytic cracking reactor, and an effluent from the second catalytic cracking reactor is separated by fractionation to produce a second dry gas, a second LPG, a second gasoline, a second diesel and a second FCC-gas oil.

15. The process according to claim 1, wherein an initial reaction temperature in the hydrogenation reactor is 350-370 ^{o}C.

16. The process according to claim 1, wherein, in step a), the effluent from the hydrogenation reactor is separated into a hydrogen-rich gas and a liquid, and the liquid is further separated to obtain the hydrogenated gas, the hydrogenated naphtha, the hydrogenated diesel, and the hydrogenated residual oil.

17. The process according to claim 16, further comprising feeding the hydrogen rich gas and a fresh hydrogen into the hydrogenation reactor.

18. The process according to claim 1, wherein the liquid hourly space velocity in the hydrogenation reactor is in a range of 0.2-0.35 h^{-1}.

19. The process according to claim 3, wherein the reaction severity in the hydrogenation reactor is increased by increasing the reaction temperature at a rate of 2-10 ^{o}C/(1000 hrs) or decreasing the liquid hourly space velocity at a rate of 0.1-0.5 h^{-1}/(1000 hrs).