Claims

1. A process for producing light olefins from inferior oils, comprises the steps of:

1) subjecting an inferior oil feedstock to a thermal conversion reaction in the presence of hydrogen to obtain a conversion product;

2) subjecting the conversion product to a first separation to obtain a first separated product, wherein the first separated product has a content of components having a boiling point below 350 ℃ of not greater than 5 wt%, preferably less than 3 wt%, and a content of components having a boiling point between 350 ℃ and 524 ℃ of 20-60 wt%, preferably 25-55 wt%;

3) subjecting the first separated product to a second separation to obtain an upgraded oil and a pitch, wherein the second separation is selected from the group consisting of vacuum distillation, solvent extraction, or a combination thereof;

4) subjecting the upgraded oil obtained in step 3) to hydro-upgrading to obtain a hydro-upgraded oil;

5) subjecting the hydro-upgraded oil obtained in step 4) to a third separation to obtain a hydro-upgraded heavy oil, wherein the third separation comprises splitting the hydro-upgraded oil into a hydro-upgraded light oil and the hydro-upgraded heavy oil, and the split point between the hydro-upgraded light oil and the hydro-upgraded heavy oil is 340-360 ℃, preferably 345-355 ℃, more preferably 350℃;

6) subjecting the hydro-upgraded heavy oil obtained in step 5) to catalytic cracking to obtain a catalytic cracking product comprising a light olefin; and

7) recycling 30-95 wt%, preferably 50-90 wt% of the pitch obtained in step 3) to step 1) for the thermal conversion reaction.

2. The process according to claim 1, wherein the thermal conversion reaction of step 1) is conducted in a slurry bed reactor.

3. The process according to any one of the preceding claims, wherein the thermal conversion reaction of step 1) is carried out in the presence of hydrogen and a conversion catalyst, wherein the conversion catalyst comprises at least one compound selected from the group consisting of Group VB metal compounds, Group VIB metal compounds and Group VIII metal compounds.

4. The process according to any one of the preceding claims, wherein the thermal conversion reaction of step 1) is carried out under conditions including:

a temperature of 380-470 ºC, a hydrogen partial pressure of 10-25 MPa, a volume space velocity of the inferior oil of 0.01-2 h^{-1}, a volume ratio of hydrogen to the inferior oil of 500-5000, and an amount of the conversion catalyst of 10-50000 μg/g calculated on the basis of the active metal in the conversion catalyst and relative to the weight of the inferior oil.

5. The process according to any one of the preceding claims, wherein the inferior oil is at least one selected from the group consisting of inferior crude oil, heavy oil, deoiled asphalt, coal derived oil, shale oil, and petrochemical waste oil,

preferably, the inferior oil satisfies one or more of the following criteria: an API degree of less than 27, a boiling point greater than 350 ºC, an asphaltene content greater than 2 wt%, and a heavy metal content greater than 100 μg/g, calculated as the total weight of nickel and vanadium.

6. The process according to any one of the preceding claims, wherein the thermal conversion reaction of step 1) is carried out to an extent that a conversion rate of 30-70 wt% is obtained, wherein the conversion rate = (weight of components having a boiling point above 524 ºC in the inferior oil - weight of components having a boiling point above 524 ºC in the conversion product)/weight of components having a boiling point above 524 ºC in the inferior oil ×100 wt%;

preferably, said thermal conversion reaction of step 1) is carried out to an extent that a conversion rate of 30-60 wt% is obtained.

7. The process according to any one of the preceding claims, wherein the first separating of step 2) comprises:

2a) separating the conversion product obtained in step 1) at a first pressure and a first temperature to obtain a gas component and a liquid component; and

2b) separating the resulting liquid component at a second pressure and a second temperature to yield the first separated product and a second separated product, wherein the first pressure is greater than the second pressure,

preferably, the first pressure is 10-25 MPa, and the first temperature is 380-470 ºC; the second pressure is 0.1-5 MPa, and the second temperature is 150-390 ºC.

8. The process according to claim 7, wherein the first separating of step 2) further comprises:

2c) splitting at least a part of the second separated product obtained in step 2b) to obtain a naphtha and an atmospheric gas oil;

2d) recycling at least a part of the gas component obtained in step 2a) to step 1) for the thermal conversion reaction; and/or

2e) recycling at least a part of the gas component obtained in step 2a) to step 4) for the hydro-upgrading.

9. The process according to claim 8, further comprising:

2f) recycling at least a part of the second separated product obtained in step 2b) and/or at least a part of the atmospheric gas oil obtained in step 2c) to step 4) for hydro-upgrading together with the upgraded oil.

10. The process according to any one of the preceding claims, wherein the hydro-upgrading of step 4) is carried out under conditions including:

a hydrogen partial pressure of 5.0-20.0 MPa, a reaction temperature of 330-450 ℃, a volume space velocity of 0.1-3 h^{-1}, and a hydrogen-to-oil volume ratio of 300-3000.

11. The process according to any one of the preceding claims, wherein the hydro-upgrading of step 4) is carried out in the presence of a hydrorefining catalyst and/or a hydrocracking catalyst, the hydrorefining catalyst comprises a carrier and an active metal component selected from Group VIB metals and/or Group VIII non-noble metals; the hydrocracking catalyst comprises a zeolite, alumina, at least one Group VIII metal component and at least one Group VIB metal component,

preferably, the hydrorefining catalyst comprises, based on the dry weight of the hydrorefining catalyst, 30-80 wt% of an alumina carrier, 5-40 wt% of molybdenum oxide, 5-15 wt% of cobalt oxide and 5-15 wt% of nickel oxide; the hydrocracking catalyst comprises, based on the dry weight of the hydrocracking catalyst, 3-60 wt% of a zeolite, 10-80 wt% of alumina, 1-15 wt% of nickel oxide, and 5-40 wt% of tungsten oxide.

12. The process according to any one of claims 1-11, wherein the catalytic cracking of step 6) is carried out in a varied-diameter dilute-phase transport bed reactor and/or a combined catalytic cracking reactor,

wherein the varied-diameter dilute-phase transport bed reactor comprises, from

bottom to top, a first reaction zone and a second reaction zone having different diameters, the ratio of the diameter of the second reaction zone to the diameter of the first reaction zone is from 1.2 : 1 to 2.0 : 1; the combined catalytic cracking reactor comprises, from bottom to top, a first reaction zone and a second reaction zone, wherein the first reaction zone is a riser reactor, and the second reaction zone is a fluidized bed reactor.

13. The process according to claim 12, wherein:

in the varied-diameter dilute-phase transport bed reactor, the reaction conditions in the first reaction zone include: a reaction temperature of 500-620 ºC, a reaction pressure of 0.2-1.2MPa, a reaction time of 0.1-5.0 seconds, a weight ratio of catalyst to cracking feedstock of 5-15, and a weight ratio of steam to cracking feedstock of 0.05 : 1 to 0.3 : 1; and the reaction conditions in the second reaction zone include: a reaction temperature of 450-550 ºC, a reaction pressure of 0.2-1.2MPa, a reaction time of 1.0-20.0 seconds, and/or

in the combined catalytic cracking reactor, the reaction conditions in the first reaction zone include: a reaction temperature of 560-750 ºC, a reaction time of 1-10 seconds, and a catalyst-oil ratio of 1 : 1 to 50 : 1; and the reaction conditions in the second reaction zone include: a reaction temperature of 550-700 ºC, and a weight space velocity of 0.5-20 h^{-1} .

14. The process according to any one of the preceding claims, wherein the catalytic cracking of step 6) is conducted in the presence of a catalytic cracking catalyst comprising, based on the weight of the catalyst, 1-60 wt% of a zeolite, 5-99 wt% of an inorganic oxide, and 0-70 wt% of clay, and wherein the zeolite comprises 50-100 wt%, preferably 70-100 wt%, of a mesoporous zeolite, and 0-50 wt%, preferably 0-30 wt%, of a macroporous zeolite, based on the total weight of the zeolite.

15. The process according to any one of the preceding claims, wherein:

the second separation of step 3) is a vacuum distillation, and the vacuum distillation is carried out at a vacuum degree of 1-20 mmHg and a temperature of 250-350 ºC; or

alternatively, the second separation of step 3) is a solvent extraction carried out under conditions including: a pressure of 3-12 MPa, preferably 3.5-10 MPa; a temperature of 55-300 ºC, preferably 70-220 ºC; an extraction solvent of C_3-C_7 hydrocarbon, preferably at least one of C_3-C_5 alkanes and C_3-C_5 alkenes, and further preferably at least

one of C_3-C_4 alkanes and C_3-C_4 alkenes; a weight ratio of extraction solvent to the first separated product of 1 : 1 to 7 : 1, preferably 1.5 : 1 to 5 : 1; or

alternatively, the second separation of step 3) is a combination of vacuum distillation and extractive separation, of which the conditions are as defined above.

16. The process according to any one of the preceding claims, wherein the pitch obtained in step 3) has a softening point of less than 150 ℃.