Claims

What is claimed:

1. A process for producing catalytic cracking gasoline comprising in a first alternative the following steps:

i) spraying a heavy feedstock oil into a riser reactor via a first nozzle, injecting the first catalytic cracking catalyst into the riser reactor at a first injection point located below the first nozzle, and subjecting the heavy feedstock oil to a catalytic cracking reaction to obtain a first reaction product;

ii) spraying a hydrogenated cycle oil into the riser reactor used in the step i) via a second nozzle, injecting the second catalytic cracking catalyst into the riser reactor at a second injection point located below the second nozzle, and subjecting the hydrogenated cycle oil to a catalytic cracking reaction to obtain a second reaction product;

iii) separating a mixture of the first reaction product and the second reaction product to obtain a catalytic cracking gasoline and a catalytic cracking light cycle oil;

iv) subjecting the catalytic cracking light cycle oil or a fraction thereof to hydrogenation to obtain a hydrogenated product; and

v) recycling the hydrogenated product to the step ii) as the hydrogenated cycle oil,

wherein, along the height direction of the riser reactor, the second nozzle is disposed above the first nozzle, and the second injection point is disposed at a position between the first nozzle and the second nozzle; or wherein the process comprises in a second alternative the following steps:

i) spraying a heavy feedstock oil into a primary riser reactor via a first nozzle, injecting the first catalytic cracking catalyst into the primary riser reactor at a first injection point located below the first nozzle, and subjecting the heavy feedstock oil to a catalytic cracking reaction to obtain a first reaction product;

ii) spraying a hydrogenated cycle oil into a secondary riser reactor via a second nozzle, injecting the second catalytic cracking catalyst into the secondary riser reactor at a second injection point located below the second nozzle, and subjecting the hydrogenated cycle oil to a catalytic cracking reaction to obtain a second reaction product;

iii) separating a mixture of the first reaction product and the second reaction product to obtain a catalytic cracking gasoline and a catalytic cracking light cycle oil;

iv) subjecting the catalytic cracking light cycle oil or a fraction thereof to hydrogenation to obtain a hydrogenated product; and

v) recycling the hydrogenated product to the step ii) as the hydrogenated cycle oil, wherein the second reaction product is fed into the upper middle portion of the primary riser reactor, where it is mixed with the first reaction product.

2. The process according to claim 1, wherein in the first alternative the reaction time in the riser reactor section between the first nozzle and the second nozzle is between about 0.05 and about 2 seconds, preferably between about 0.1 and about 1 second.

3. The process according to claim 1 or 2, wherein in the first alternative the reaction conditions in the riser reactor are as follows: a reaction temperature ranging from about 450 to about 650 °C, preferably from about 490 to about 550 °C, an absolute pressure ranging from about 0.15 to about 0.4 MPa, a weight ratio of the total weight of the first and second catalytic cracking catalysts to the heavy feedstock oil ranging from about 1 to about 50, preferably from about 3 to about 30, a reaction time of the heavy feedstock oil ranging from about 1 to about 10 seconds, preferably from about 2 to about 8 seconds, and a weight ratio of steam to the heavy feedstock oil ranging from about 0.01 to about 0.5, preferably from about 0.02 to about 0.2; a weight ratio of the total weight of the first and second catalytic cracking catalysts to the hydrogenated cycle oil ranging from about 5 to about 100, preferably from about 8 to about 50, a reaction time of the hydrogenated cycle oil ranging from about 1 to about 10 seconds, preferably from about 2 to about 8 seconds, and a weight ratio of steam to the hydrogenated cycle oil ranging from about 0.01 to about 0.3, preferably from about 0.01 to about 0.1, with both the first catalytic cracking catalyst and the second catalytic cracking catalyst having a micro-activity of no less than about 60, preferably no less than about 62.

4. The process according to claim 1, wherein in the second alternative the reaction conditions in the primary riser reactor are as follows: a reaction temperature ranging from about 450 to about 550 °C, preferably from about 500 to about 520 °C, a weight ratio of the first catalytic cracking catalyst to the heavy feedstock oil ranging from about 4 to about 8, preferably from about 5 to about 7, a reaction time ranging from about 2 to about 10 seconds, preferably from about 2 to about 8 seconds, an absolute pressure ranging from about 0.15 to about 0.4 MPa, a weight ratio of steam to the heavy feedstock oil ranging from about 0.02 to about 0.08, preferably from about 0.03 to about 0.05, and a micro-activity of the first catalytic cracking catalyst of no less than about 60, preferably no less than about 62; and/or the reaction conditions in the secondary riser reactor are as follows: a reaction temperature ranging from

about 520 to about 650 °C, preferably from about 550 to about 590 °C, an absolute pressure ranging from about 0.15 to about 0.4 MPa, a weight ratio of the second catalytic cracking catalyst to the hydrogenated cycle oil ranging from about 5 to about 100, preferably from about 8 to about 50, a reaction time ranging from about 1 to about 10 seconds, preferably from about 1 to about 8 seconds, a weight ratio of steam to the hydrogenated cycle oil ranging from about 0.01 to about 0.3, preferably from about 0.02 to about 0.2, and a micro-activity of the second catalytic cracking catalyst of no less than about 60, preferably no less than about 62.

5. The process according to any one of claims 1 to 4, wherein the weight ratio of the first catalytic cracking catalyst to the second catalytic cracking catalyst is in a range from about 1:0.02 to about 1:1, preferably from about 1:0.03 to about 1:0.5.

6. The process according to any one of claims 1 to 5, wherein the riser reactor is an equal-diameter riser reactor with or without a fluidized bed reactor, or a variable-diameter riser reactor with or without a fluidized bed reactor.

7. The process according to claim 1 or 4, wherein in the second alternative the primary riser reactor comprises a first reaction section and a second reaction section that are coaxially arranged from bottom to top, with the inner diameter of the second reaction section being larger than that of the first reaction section, and the outlet of the secondary riser reactor is connected to the second reaction section via a horizontal pipe.

8. The process according to any one of claims 1 to 7, further comprising:

splitting the catalytic cracking light cycle oil into a light fraction and a heavy fraction prior to the step iv), and subjecting the heavy fraction to hydrogenation in the step iv) to obtain the hydrogenated product; and recycling the light fraction to the step ii) and subjecting it to a catalytic cracking reaction in the presence of the second catalytic cracking catalyst.

9. The process according to claim 8, wherein the catalytic cracking light cycle oil is split at a cut point between about 240 and about 260 °C.

10. The process according to any one of claims 1 to 9, wherein the heavy feedstock oil is selected from the group consisting of straight-run wax oil, coker wax oil, deasphalted oil, hydrorefined oil, hydrocracking tail oil, vacuum residue, atmospheric residue, and

combinations thereof.

11. The process according to any one of claims 1 to 10, wherein the first catalytic cracking catalyst and the second catalytic cracking catalyst each independently comprises, on a dry basis, about 10% to about 50% by weight of a zeolite, about 5% to about 90% by weight of an inorganic oxide and about 0% to about 70% by weight of a clay, based on the weight of the catalytic cracking catalyst; the zeolite is selected from the group consisting of a Y zeolite with or without a rare earth element, an HY zeolite with or without a rare earth element, a USY zeolite with or without a rare earth element, a Beta zeolite with or without a rare earth element, and combinations thereof; the inorganic oxide is selected from the group consisting of silica, alumina, and combinations thereof; and the clay is selected from kaolin and/or halloysite.

12. The process according to any one of claims 1 to 11, wherein the step iv) is carried out in the presence of a hydrogenation catalyst comprising an active metallic component and a support, said active metallic component is a Group VIB metal and/or a Group VIII non-noble metal, and the support is selected from the group consisting of alumina, silica, amorphous silica-alumina, and combinations thereof; preferably, the hydrogenation catalyst comprises about 15% to about 30% by weight of the active metallic component and about 70% to about 85% by weight of the support.

13. The process according to claim 12, wherein the active metallic component is nickel-tungsten, nickel-tungsten-cobalt, nickel-molybdenum or cobalt-molybdenum.

14. The process according to any one of claims 1 to 13, wherein the hydrogenation conditions employed in the step iv) are as follows: a hydrogen partial pressure ranging from about 5.0 to about 22.0 MPa, preferably from about 8.0 to about 15.0 MPa, a reaction temperature ranging from about 330 to about 450 °C, preferably from about 340 to about 380 °C, a volume space velocity ranging from about 0.1 to about 10.0 h^{-1}, preferably from about 0.1 to about 3.0 h^{-1}, and a hydrogen-to-oil volume ratio ranging from about 100 to about 2000 Nm^3/m^3, preferably from about 350 to about 1200 Nm^3/m^3.

15. A catalytic cracking system for carrying out the process according to claim 1, comprising a primary riser reactor, a secondary riser reactor, a regenerator, a disengager, a main fractionation column, a light cycle oil fractionation column, and a hydrogenation reactor,

wherein:

the primary riser reactor is provided with a lower feed inlet, a bottom catalyst inlet and a top outlet, the secondary riser reactor is provided with a first feed inlet and a second feed inlet at a lower portion, a bottom catalyst inlet and a top outlet, and the top outlet of the secondary riser reactor is connected to the upper middle portion of the primary riser reactor via a horizontal pipe,

the top outlet of the primary riser reactor is connected to an inlet of the disengager, a catalyst outlet of the disengager is connected to the regenerator, an oil-gas outlet of the disengager is connected to an inlet of the main fractionation column, and a light cycle oil outlet of the main fractionation column is connected to an inlet of the light cycle oil fractionation column,

a heavy fraction outlet of the light cycle oil fractionation column is connected to an inlet of the hydrogenation reactor, a light fraction outlet of the light cycle oil fractionation column is connected to the second feed inlet of the secondary riser reactor, and a hydrogenated product outlet of the hydrogenation reactor is connected to the first feed inlet of the secondary riser reactor, and

a regenerated catalyst outlet of the regenerator is connected to the catalyst inlet of the primary riser reactor and the catalyst inlet of the secondary riser reactor, respectively.

16. The system according to claim 15, wherein the primary riser reactor comprises a first reaction section and a second reaction section that are coaxially arranged from bottom to top, with the inner diameter of the second reaction section being larger than that of the first reaction section, and the top outlet of the secondary riser reactor is connected to the second reaction section via a horizontal pipe.