separator is conducted to a product recovery section, whereby a CO_2-rich fraction is withdrawn. A portion of lighter materials (LPG analogue) from downstream fractionation is optionally conducted to a hydrogen generation unit, thereby producing hydrogen which is used in the process, optionally together with an external source of make-up hydrogen.

SUMMARY

We have found that apart from the reduction of the total consumption of hydrogen, it is now also possible to integrate a renewable feed hydrotreatment unit with a hydrogen production unit and minimize the energy consumption for the overall process/plant, mainly by minimizing natural gas consumption for production of hydrogen required for hydro-processing of the renewable feed, thereby drastically reducing the carbon dioxide footprint of the plant.

In a first aspect of the present disclosure, there is provided a process for producing a hydrocarbon product, said process comprising the steps of:

i) passing a feedstock originating from a renewable source through a hydroprocessing stage for producing a main hydrotrotreated stream;

ii) passing the main hydrotreated stream to a separation stage for producing:

an aqueous stream,

a hydrogen-rich stream as a first recycle gas stream,

an off-gas stream comprising hydrocarbons,

and said hydrocarbon product, boiling at above 50°C;

iii) passing the first recycle gas stream to the hydroprocessing stage;

iv) passing the off-gas stream as a second recycle gas stream to a hydrogen producing unit for producing a hydrogen stream as a make-up hydrogen stream;

v) passing the make-up hydrogen stream to the hydroprocessing stage;

wherein prior to conducting step iv), said off-gas stream passes to a separation stage for removing H_2S and thereby producing said second recycle gas stream.

In a second aspect of the present disclosure, there is provided a plant for producing a hydrocarbon product, comprising:

- a hydroprocessing section arranged to receive a feedstock originating from a renewable source and a compressed hydrogen-rich feed stream for producing a main hydrotreated stream;
- a separation section arranged to receive said main hydrotreated stream for producing an aqueous stream, a hydrogen-rich stream as a first recycle gas stream, an off-gas stream comprising hydrocarbons as a second recycle stream, and said hydrocarbon product, boiling at above 50°C;
- a separation section for removing H_2S and thereby producing said second recycle gas stream;
- a hydrogen producing unit (HPU) arranged to receive said second recycle gas stream and a hydrocarbon feedstock for producing a make-up hydrogen stream;
- a compressor section arranged to receive said first recycle gas stream and at least a portion of the make-up hydrogen stream produced in said HPU, for generating said compressed hydrogen-rich feed stream and a make-up hydrogen recycle stream;
- a conduit for passing said first recycle gas stream to said compressor section;
- a conduit for passing said make-up hydrogen stream from the HPU to said compressor section.

Accordingly, in a first example, the present disclosure provides a process for producing a hydrocarbon product, said process comprising the steps of:

i) passing a feedstock originating from a renewable source through a hydroprocessing stage for producing a main hydrotrotreated stream;

ii) passing the main hydrotreated stream to a separation stage for producing:

an aqueous stream;

a hydrogen-rich stream as a first recycle gas stream;

an off-gas stream comprising hydrocarbons;

and said hydrocarbon product, boiling at above 50°C;

CLAIMS

1. A process for producing a hydrocarbon product, said process comprising the steps of:

i) passing a feedstock originating from a renewable source through a hydroprocessing stage for producing a main hydrotrotreated stream;

ii) passing the main hydrotreated stream to a separation stage for producing:

an aqueous stream,

a hydrogen-rich stream as a first recycle gas stream,

an off-gas stream comprising hydrocarbons,

and said hydrocarbon product, boiling at above 50°C;

iii) passing the first recycle gas stream to the hydroprocessing stage;

iv) passing the off-gas stream as a second recycle gas stream to a hydrogen producing unit for producing a hydrogen stream as a make-up hydrogen stream;

v) passing the make-up hydrogen stream to the hydroprocessing stage;

wherein prior to conducting step iv), said off-gas stream passes to a separation stage for removing H_2S and thereby producing said second recycle gas stream.

2. The process according to claim 1, wherein the process further comprises: vi) splitting said hydrogen-rich stream into said first recycle gas stream and a third recycle gas stream, and passing said third recycle gas stream to said hydrogen producing unit.

3. The process according to claim 1 or 2, wherein in step i) the hydroprocessing stage comprises:

i-1) passing the feedstock through a first catalytic hydrotreating unit under the addition of hydrogen for producing a first hydrotreated stream;

i-2) passing the first hydrotreated stream to a dewaxing section comprising a second catalytic hydrotreating unit under the addition of hydrogen for producing said main hydrotreated stream.

4. The process according to claim 3, wherein between step i-1) and i-2) the process further comprises passing the first hydrotreated stream to a separator, such as a high-pressure or low-pressure separator, for removing H_2S, NH_3, and H_2O, thereby

producing said first hydrotreated stream, and optionally also producing a vapor stream, and a recycle oil stream.

5. The process according to any of claims 1-4, wherein in step ii) the separation stage comprises:
ii-1) passing the main hydrotreated stream to a separator, preferably a cold separator, for producing said aqueous stream, said hydrogen-rich stream, and a heavy hydrocarbon stream;
ii-2) passing the heavy hydrocarbon stream to a fractionation section for producing said off-gas stream, and said hydrocarbon product.

6. The process according to any of claims 1-5, wherein in step v) the make-up hydrogen stream passes to at least one of:
said first catalytic hydrotreating unit;
said separator between step i-1) and i-2), such as a high pressure stripper;
second catalytic hydrotreating unit;
and optionally also an additional catalytic hydrotreating unit such as a third catalytic hydrotreating unit.

7. The process according to any of claims 1-6, wherein the hydrogen producing unit comprises feeding: said second recycle gas stream, and a hydrocarbon feedstock such as natural gas, optionally together with one or more of said hydrocarbon products, preferably naphtha.

8. The process according to any of claims 1-7, wherein the hydrogen producing unit comprises subjecting the hydrocarbon feedstock to: cleaning in a cleaning unit, said cleaning unit preferably being a sulfur-chlorine-metal absorption or catalytic unit; optionally pre-reforming in a pre-reforming unit; catalytic steam methane reforming in a steam reforming unit; water gas shift conversion in a water gas shift unit; optionally carbon dioxide removal in a CO_2-separator unit; and hydrogen purification in a hydrogen purification unit.

9. The process according to claim 8, wherein said second recycle gas stream is fed to the cleaning unit.

10. The process according to any of claims 1-9, wherein the hydrogen-rich stream, or first recycle stream, or third recycle stream comprises hydrogen in a concentration of 50 vol% or higher, and wherein any of said streams is passed through a hydrogen purification unit: prior to splitting said hydrogen-rich stream into a first recycle stream or a third recycle stream, or prior to passing the first recycle stream to the hydroprocessing stage, or prior to passing said third recycle stream to the hydrogen producing unit.

11. The process according to claim 9, wherein the hydrogen purification unit is the hydrogen purification unit of the hydrogen producing unit, and said third recycle stream is passed through this hydrogen purification unit.

12. The process according to claim 11, wherein the hydrogen purification unit is a Pressure Swing Adsorption unit (PSA unit), said PSA unit producing an off-gas stream which is used as fuel in the steam reforming unit of the hydrogen producing unit, and/or in fired heaters in any of the catalytic hydrotreating units of the hydroprocessing stage, separation units of the separation stage, and/or for steam production.

13. The process according to any of claims 9-12, wherein the steam reforming unit is: a convection reformer, a tubular reformer, autothermal reformer (ATR), electrically heated steam methane reformer (e-SMR), or any combination thereof.

14. The process according to any of claims 1-13, wherein prior to passing the make-up hydrogen stream to the hydroprocessing stage, the make-up hydrogen stream passes through a compressor section comprising a make-up compressor optionally also a recycle compressor, the make-up compressor also producing a hydrogen recycle stream which is added to the hydrogen producing unit, preferably directly to the second recycle stream entering the hydrogen producing unit, and/or to the cleaning unit of the hydrogen producing unit.

15. The process according to any of claims 1-14, wherein the feedstock is obtained from a raw material of renewable origin, such as originating from plants, algae, animals, fish, vegetable oil refining, domestic waste, waste rich in plastic, industrial

organic waste like tall oil or black liquor, or a feedstock derived from one or more oxygenates taken from the group consisting of triglycerides, fatty acids, resin acids, ketones, aldehydes or alcohols where said oxygenates originate from one or more of a biological source, a gasification process, a pyrolysis process, Fischer-Tropsch synthesis, or methanol based synthesis.

16. The process according to any of claims 1-15, wherein step i) also comprises adding a feedstock originating from a fossil fuel source, such as diesel, kerosene, naphtha, and vacuum gas oil (VGO), and/or recycling a hydrocarbon product.

17. The process according to any of claims 1-16, wherein the separation stage is at least one of an amine absorption stage, a caustic scrubber, and a sulfur absorbent.

18. The process according to any of claims 1-17, wherein the first recycle gas stream is not subjected to a separation stage for removing H_2S and/or CO_2, optionally also for removing NH_3 and/or CO, prior to being passed to the hydroprocessing stage.

19. A plant for producing a hydrocarbon product, comprising:
- a hydroprocessing section arranged to receive a feedstock originating from a renewable source and a compressed hydrogen-rich feed stream for producing a main hydrotreated stream;
- a separation section arranged to receive said main hydrotreated stream for producing an aqueous stream, a hydrogen-rich stream as a first recycle gas stream, an off-gas stream comprising hydrocarbons as a second recycle stream, and said hydrocarbon product, boiling at above 50°C;
- a separation section, for removing H_2S and thereby producing said second recycle gas stream;
- a hydrogen producing unit (HPU) arranged to receive said second recycle gas stream and a hydrocarbon feedstock for producing a make-up hydrogen stream;
- a compressor section arranged to receive said first recycle gas stream and at least a portion of the make-up hydrogen stream produced in said HPU, for generating said compressed hydrogen-rich feed stream and a make-up hydrogen recycle stream;
- a conduit for passing said first recycle gas stream to said compressor section;

- a conduit for passing said make-up hydrogen stream from the HPU to said compressor section.

20. The plant of claim 19, wherein the separation section is at least one of an amine absorption stage, a caustic scrubber, and a sulfur absorbent, arranged to receive said off-gas stream.

21. The plant of claim 19 or 20, further comprising a conduit for recycling said make-up hydrogen recycle stream to the HPU.

22. The plant of any of claims 19-21, further comprising means for splitting said hydrogen-rich stream into said first recycle gas stream and a third recycle gas stream, and a conduit for passing said third recycle gas stream to said HPU.