

SUMMARY

A hydrotreatment unit for an oxygenate feedstock is thus provided, said unit comprising:

- a hydrotreatment reactor; said hydrotreatment reactor being arranged to receive said oxygenate feedstock and convert it to a hydrotreated first hydrocarbon stream;
- 5 - a first cooling unit arranged to receive said hydrotreated first hydrocarbon stream from said hydrotreatment reactor and cool it to a cooled second hydrocarbon stream;
- a high-pressure separator arranged to receive the cooled second hydrocarbon stream from said first cooling unit and separate it into at least a hydrocarbon-rich stream, and a hydrogen-rich stream;
- 10 - a low pressure flash unit, said low pressure flash unit arranged to receive the hydrocarbon-rich stream from said high-pressure separator unit and de-gas it; thereby providing an off-gas and a degassed hydrocarbon-rich stream,
- wherein said hydrotreatment unit is arranged to feed at least a part of the hydrogen-rich stream from the high-pressure separator to the hydrotreatment reactor; and
- 15 - wherein said hydrotreatment unit is arranged to feed a part of the degassed hydrocarbon-rich stream from said low pressure flash unit as a hydrocarbon recycle stream to the hydrotreatment reactor

with the associated benefit of providing a recycle configuration with a high gas purity.

20 In one aspect of the present disclosure, there is provided a hydrotreatment unit for an oxygenate feedstock, said unit comprising:

- a hydrotreatment reactor; said hydrotreatment reactor being arranged to receive said oxygenate feedstock and convert it to a hydrotreated first hydrocarbon stream;
- a first cooling unit arranged to receive said hydrotreated first hydrocarbon stream from said hydrotreatment reactor and cool it to a cooled second hydrocarbon stream;
- 25 - a high-pressure separator arranged to receive the cooled second hydrocarbon stream from said first cooling unit and separate it into at least a hydrocarbon-rich stream, and a H₂-rich stream;

- a low pressure flash unit, said low pressure flash unit arranged to receive the hydrocarbon-rich stream from said high-pressure separator unit and de-gas it; thereby providing an off-gas and a degassed hydrocarbon-rich stream.
- wherein said hydrotreatment unit is arranged to feed at least a part of the hydrogen-rich stream from the high-pressure separator to the hydrotreatment reactor; and
- wherein said hydrotreatment unit is arranged to feed a part of the degassed hydrocarbon-rich stream from said low pressure flash unit as a hydrocarbon recycle stream to the hydrotreatment reactor.

In another aspect of the present disclosure, there is provided a diesel plant comprising the hydrotreatment unit disclosed herein, and a separation unit, said diesel plant arranged such that at least a part of said degassed hydrocarbon-rich stream, is fed from said hydrotreatment unit to said separation unit and purified to provide at least a diesel and/or a jet product.

In a further aspect of the present disclosure, there is provided a method for hydrotreating an oxygenate feedstock using the hydrotreatment unit disclosed herein, said method comprising the steps of:

- i. feeding said oxygenate feedstock to the hydrotreatment reactor; and converting it to a hydrotreated first hydrocarbon stream;
- ii. feeding said hydrotreated first hydrocarbon stream from said hydrotreatment reactor to said first cooling unit and cooling it to a cooled second hydrocarbon stream;
- iii. feeding the cooled second hydrocarbon stream from said first cooling unit to said high-pressure separator, and separating it into at least a hydrocarbon-rich stream, and a hydrogen-rich stream;
- iv. feeding the hydrocarbon-rich stream from said high-pressure separator to said low pressure flash unit, and de-gassing it; thereby providing an off-gas and a degassed hydrocarbon-rich stream.
- v. feeding at least a part of the hydrogen-rich stream from the high-pressure separator to the hydrotreatment reactor;
- vi. separating the degassed hydrocarbon-rich stream from the low pressure flash unit into a hydrocarbon product stream and a hydrocarbon recycle stream; and
- vii. feeding said hydrocarbon recycle stream to the hydrotreatment reactor.

In a further ~~embodiment~~example the hydrotreatment unit further comprises a hydroisomerization section located between said hydrotreatment reactor and said first cooling unit; and being arranged to receive said hydrotreated first hydrocarbon stream from said hydrotreatment reactor, perform catalytic hydroisomerization of said hydrotreated first

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hydrocarbon stream and provide a dewaxed first hydrocarbon stream to said first cooling unit with the associated benefit of providing a dewaxed hydrocarbon stream with good cold flow properties.

5 In a further ~~embodiment~~example the hydrotreatment unit further comprises a second heating or cooling unit located in said hydrotreated first hydrocarbon stream between said hydrotreatment reactor and said hydroisomerization section with the associated benefit of providing optimal conditions in said hydroisomerization section.

In a further ~~embodiment~~example of the hydrotreatment unit said hydrotreatment unit is arranged to provide a part of the degassed hydrocarbon-rich stream from said low pressure flash unit as a hydrocarbon product stream with the associated benefit of providing a commercial product from the hydrotreatment unit.

- 5 In a further ~~embodiment~~example of the hydrotreatment unit said off-gas comprises H₂, CO₂, C1 and C3 gaseous components with the associated benefit of withdrawing an amount of CO₂, C1 and C3 instead of directing it to the hydrotreatment reactor.

- 10 In a further ~~embodiment~~example the hydrotreatment unit further comprises an H₂ make-up feed, arranged to be combined with said H₂-rich stream so as to provide treat gas with the associated benefit of providing a high amount of H₂ in the treat gas.

In a further ~~embodiment~~example the hydrotreatment unit further comprises a first compressor arranged to compress the H₂-rich stream, with the associated benefit of providing the H₂-rich stream at high pressure conditions matching the pressure in the hydrotreatment unit.

- 15 In a further ~~embodiment~~example the hydrotreatment unit is arranged to combine said H₂-rich stream or said treat gas with said hydrocarbon recycle stream to provide a combined stream which is fed to the hydrotreatment reactor, with the associated benefit of providing H₂ to the reaction in the hydrotreatment unit.

- 20 In a further ~~embodiment~~example the hydrotreatment unit is arranged to combine at least an amount of said combined stream with at least a portion of oxygenate feedstock prior to being fed to the hydrotreatment reactor, with the associated benefit of providing H₂ to the reaction in the hydrotreatment unit, as well as the benefit of stepwise control of the reactor temperature, by adding an amount of cooled combined stream at an intermediate point in the reactor.

- 25 A further ~~aspect~~example relates to a diesel plant comprising the hydrotreatment unit and a separation unit, said diesel plant arranged such that at least a part of said degassed hydrocarbon-rich stream, is fed from said hydrotreatment unit to said separation unit and purified to provide a hydrocarbon product, such as a diesel product, jet fuel or feedstock to a petrochemical plant.

A further aspect relates to a method for hydrotreating an oxygenate feedstock using the hydrotreatment unit comprising the steps of:

- 30 i. feeding said oxygenate feedstock to the hydrotreatment reactor; and converting it to a hydrotreated first hydrocarbon stream;

- ii. feeding said hydrotreated first hydrocarbon stream from said hydrotreatment reactor to said first cooling unit and cooling it to a cooled second hydrocarbon stream;
- iii. feeding the cooled second hydrocarbon stream from said first cooling unit to said high-pressure separator, and separating it into at least a hydrocarbon-rich stream,
5 and a hydrogen-rich stream;
- iv. feeding the hydrocarbon-rich stream from said high-pressure separator to said low pressure flash unit, and de-gassing it; thereby providing an off-gas and a degassed hydrocarbon-rich stream,
- v. feeding at least a part of the hydrogen-rich stream from the high-pressure separator
10 to the hydrotreatment reactor;
- vi. separating the degassed hydrocarbon-rich stream from the low pressure flash unit into a hydrocarbon product stream and a hydrocarbon recycle stream; and
- vii. feeding said hydrocarbon recycle stream to the hydrotreatment reactor.

15 In a further ~~embodiment~~example of the method the low pressure flash unit operates at a pressure of between ambient pressure and 30 barg, preferably between ambient pressure and 15 barg, with the associated benefit of separating an off-gas comprising other gases than H₂ as well as a moderate amount of H₂ from the degassed hydrocarbon-rich stream.

20 In a further ~~embodiment~~example of the method the high pressure separator operates at a pressure of between 20-100 barg, preferably between 30-80 barg with the associated benefit of separating a hydrogen-rich stream comprising a moderate amount of other gases than hydrogen from the hydrocarbon-rich stream, such as 80 vol% H₂ or more.

25 In a further ~~embodiment~~example the method further comprises a step of performing catalytic hydroisomerization on the hydrotreated first hydrocarbon stream from said hydrotreatment reactor, and providing a dewaxed first hydrocarbon stream to said first cooling unit, with the associated benefit of carrying out hydroisomerization on sulfided base metal catalyst in the presence of sulfur.

30 In a further ~~embodiment~~example of the method the hydrogen-rich stream from the high-pressure separator is further cooled and separated in a further cold high-pressure separator before being directed to the hydrotreatment reactor; with the associated benefit of the hydrogen-rich stream comprising an even lower amount of other gases than hydrogen from the hydrocarbon-rich stream, such as 80 vol% H₂ or more. The liquid of the cold high-pressure separator may be further separated in a low pressure separator and may either be directed as a hydrocarbon recycle stream to the hydrotreatment reactor or to a fractionator for separation into product.

Claims

1. A hydrotreatment unit ~~(10)~~ for an oxygenate feedstock ~~(11)~~, said unit ~~(10)~~ comprising:
 - 5 - a hydrotreatment reactor ~~(20)~~; said hydrotreatment reactor ~~(20)~~ being arranged to receive said oxygenate feedstock ~~(11)~~ and convert it to a hydrotreated first hydrocarbon stream ~~(21)~~;
 - a first cooling unit ~~(30)~~ arranged to receive said hydrotreated first hydrocarbon stream ~~(21)~~ from said hydrotreatment reactor ~~(20)~~ and cool it to a cooled second hydrocarbon stream ~~(31)~~;
 - 10 - a high-pressure separator ~~(40)~~ arranged to receive the cooled second hydrocarbon stream ~~(31)~~ from said first cooling unit ~~(30)~~ and separate it into at least a hydrocarbon-rich stream ~~(41)~~, and a H₂-rich stream ~~(42)~~;
 - a low pressure flash unit ~~(50)~~, said low pressure flash unit ~~(50)~~ arranged to receive the hydrocarbon-rich stream ~~(41)~~ from said high-pressure separator unit ~~(40)~~ and de-

15 gas it; thereby providing an off-gas ~~(56)~~ and a degassed hydrocarbon-rich stream ~~(52)~~,

 - wherein said hydrotreatment unit ~~(10)~~ is arranged to feed at least a part of the hydrogen-rich stream ~~(42)~~ from the high-pressure separator ~~(40)~~ to the hydrotreatment reactor ~~(20)~~; and

20 - wherein said hydrotreatment unit ~~(10)~~ is arranged to feed a part of the degassed hydrocarbon-rich stream ~~(52)~~ from said low pressure flash unit ~~(50)~~ as a hydrocarbon recycle stream ~~(54)~~ to the hydrotreatment reactor ~~(20)~~.

2. The hydrotreatment unit ~~(10)~~ according to claim 1, further comprising a

25 hydroisomerization section ~~(70)~~ located between said hydrotreatment reactor ~~(20)~~ and said first cooling unit ~~(30)~~; and being arranged to receive said hydrotreated first hydrocarbon stream ~~(21)~~ from said hydrotreatment reactor ~~(20)~~, perform catalytic hydroisomerization of said hydrotreated first hydrocarbon stream ~~(21)~~ and provide a dewaxed first hydrocarbon stream ~~(23)~~ to said first cooling unit ~~(30)~~.

3. The hydrotreatment unit ~~(10)~~ according to claim 2, further comprising a second

30 heating or cooling unit ~~(39)~~ located in said hydrotreated first hydrocarbon stream ~~(21)~~ between said hydrotreatment reactor ~~(20)~~ and said hydroisomerization section ~~(70)~~.

4. The hydrotreatment unit ~~(10)~~ according to any one of the preceding claims, wherein said hydrotreatment unit ~~(10)~~ is arranged to provide a part of the degassed hydrocarbon-rich stream ~~(52)~~ from said low pressure flash unit ~~(50)~~ as a hydrocarbon product stream ~~(53)~~.

5. The hydrotreatment unit ~~(10)~~ according to any one of the preceding claims wherein said off-gas ~~(56)~~ comprises H₂, CO₂, C1 and C3 gaseous components.
6. The hydrotreatment unit ~~(10)~~ according to any one of the preceding claims, further comprising an H₂ make-up feed ~~(12)~~, arranged to be combined with said H₂-rich stream ~~(42)~~ so as to provide treat gas ~~(43)~~.
7. The hydrotreatment unit ~~(10)~~ according to any one of the preceding claims, further comprising a first compressor ~~(60)~~ arranged to compress the H₂-rich stream ~~(42)~~.
8. The hydrotreatment unit ~~(10)~~ according to any one of the preceding claims, wherein said hydrotreatment unit ~~(10)~~ is arranged to combine said H₂-rich stream ~~(42)~~ or said treat gas ~~(43)~~ with said hydrocarbon recycle stream ~~(54)~~ to provide a combined stream ~~(55)~~ which is fed to the hydrotreatment reactor ~~(20)~~.
9. The hydrotreatment unit ~~(10)~~ according to any one of the preceding claims, wherein said hydrotreatment unit ~~(10)~~ is arranged to combine said at least an amount of combined stream ~~(55)~~ with at least a portion of the oxygenate feedstock ~~(11)~~ prior to being fed to the hydrotreatment reactor ~~(20)~~.
10. A diesel plant comprising the hydrotreatment unit ~~(10)~~ according to any one of the preceding claims, and a separation unit, said diesel plant arranged such that at least a part of said degassed hydrocarbon-rich stream ~~(52)~~, is fed from said hydrotreatment unit ~~(10)~~ to said separation unit and purified to provide at least a diesel and/or a jet product.
11. A method for hydrotreating an oxygenate feedstock ~~(11)~~ using the hydrotreatment unit ~~(10)~~ according to any one of claims 1-9, said method comprising the steps of:
 - i. feeding said oxygenate feedstock ~~(11)~~ to the hydrotreatment reactor ~~(20)~~; and converting it to a hydrotreated first hydrocarbon stream ~~(21)~~;
 - ii. feeding said hydrotreated first hydrocarbon stream ~~(21)~~ from said hydrotreatment reactor ~~(20)~~ to said first cooling unit ~~(30)~~ and cooling it to a cooled second hydrocarbon stream ~~(31)~~;
 - iii. feeding the cooled second hydrocarbon stream ~~(31)~~ from said first cooling unit ~~(30)~~ to said high-pressure separator ~~(40)~~, and separating it into at least a hydrocarbon-rich stream ~~(41)~~, and a hydrogen-rich stream ~~(42)~~;
 - iv. feeding the hydrocarbon-rich stream ~~(41)~~ from said high-pressure separator ~~(40)~~ to said low pressure flash unit ~~(50)~~, and de-gassing it; thereby providing an off-gas ~~(56)~~ and a degassed hydrocarbon-rich stream ~~(52)~~,

- v. feeding at least a part of the hydrogen-rich stream ~~(42)~~ from the high-pressure separator ~~(40)~~ to the hydrotreatment reactor ~~(20)~~;
 - vi. separating the degassed hydrocarbon-rich stream ~~(52)~~ from the low pressure flash unit ~~(40)~~ into a hydrocarbon product stream ~~(53)~~ and a hydrocarbon recycle stream ~~(54)~~; and
 - vii. feeding said hydrocarbon recycle stream ~~(54)~~ to the hydrotreatment reactor ~~(20)~~.
12. The method according to claim 11, wherein the low pressure flash unit ~~(40)~~ operates at a pressure of between ambient pressure and 30 barg, preferably between ambient pressure and 15 barg.
13. The method according to any one of claims 11-12, wherein the high pressure separator ~~(40)~~ operates at a pressure of between 20-100 barg, preferably between 30-80 barg.
14. The method according to any one of claims 11-13, further comprising a step of performing catalytic hydroisomerization on the hydrotreated first hydrocarbon stream ~~(21)~~ from said hydrotreatment reactor ~~(20)~~, and providing a dewaxed first hydrocarbon stream ~~(23)~~ to said first cooling unit ~~(30)~~.