



(51) International Patent Classification:
F25J 1/00 (2006.01) F25J 1/02 (2006.01)

(21) International Application Number:
PCT/EP2018/054645

(22) International Filing Date:
26 February 2018 (26.02.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
17158442.8 28 February 2017 (28.02.2017) EP

(71) Applicant (for all designated States except US): SHELL
INTERNATIONALE RESEARCH MAATSCHAPPIJ
B.V. [NL/NL]; Carel van Bylandtlaan 30, 2596 HR THE
HAGUE (NL).

(71) Applicant (for US only): SHELL OIL COMPANY
[US/US]; 150 N. Dairy Ashford, HOUSTON, TX 77079
(US).

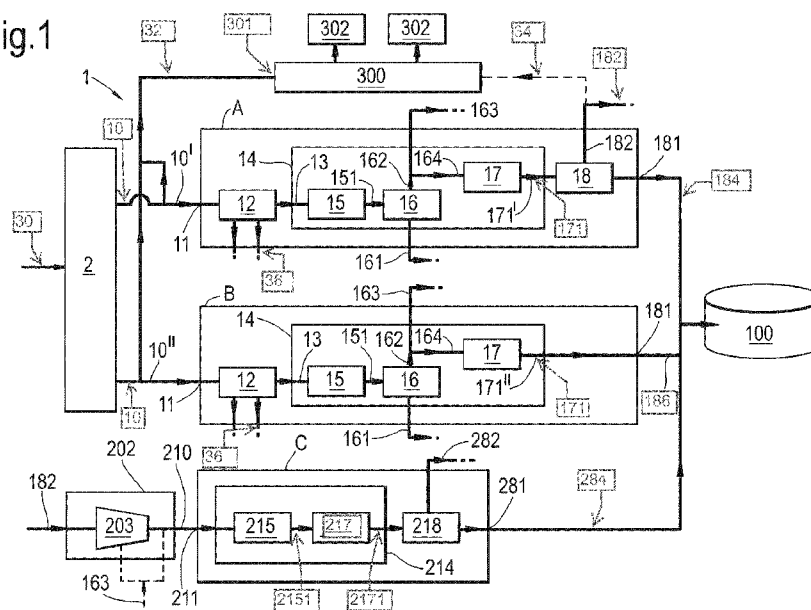
(72) Inventors: JAGER, Marco, Dick; Vondelingenweg 601,
3196KK VONDELINGENPLAAT ROTTERDAM (NL).
MEIRING, Wouter, Jan; Kesslerpark 1, 2688 GS
RIJSWIJK (NL).

(74) Agent: SHELL LEGAL SERVICES IP; PO Box 384,
2501 CJ THE HAGUE (NL).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP,
KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,

(54) Title: LIQUID NATURAL GAS PLANT AND METHOD OF OPERATING THEREOF

Fig.1



(57) Abstract: The invention relates to a liquid natural gas plant (1) for producing liquefied natural gas. The liquid natural gas plant (1) comprises two or more parallel treatment and liquefaction trains (A, B), each train comprising a cooling stage (14) arranged to receive a cleaned natural gas stream (13) from a gas treatment stage (12), an NGL- extraction unit (16) for extracting natural gas liquids (161), thereby generating a light natural gas stream (162). The liquid natural gas plant (1) comprises an additional liquefaction train (C), comprising an additional cooling stage (214) arranged to receive an additional feed stream for generating additional liquefied natural gas. The additional feed stream (210) comprises two or more side streams taken from the light natural gas taken from the respective light natural gas streams (163) of the one or more parallel treatment and liquefaction trains (A, B).

MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

- *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

LIQUID NATURAL GAS PLANT AND METHOD OF OPERATING THEREOF

FIELD OF THE INVENTION

The present invention is directed to liquid natural gas plant comprising a plurality of treatment and liquefaction trains. The invention is further related to a method of retrofitting and/or operating such a liquid natural gas plant.

BACKGROUND TO THE INVENTION

Natural gas can be liquefied for purposes of storage and transportation, as it is occupying a smaller volume in liquid state than in gaseous state. Typically, before being liquefied, the natural gas is treated to remove contaminants (such as H₂O, CO₂, H₂S and the like) and heavy hydrocarbon molecules, which may freeze out during the liquefaction process.

Liquefaction of natural gas is an energy consuming process. Designing and operating liquid natural gas plants in the most efficient manner is therefore a constant focus area.

WO2006/120127 describes an LNG plant having a single liquefaction train for providing LNG in liquid or "pseudo-liquid" form. The LNG in liquid or "pseudo-liquid" form is sent into a separation unit for providing purified LNG and a nitrogen-enriched stream.

WO201576975 describes a method of retrofitting a full-scale LNG plant to enhance the LNG production capacity of the LNG plant and a method for operating such a retrofit plant. A small scale LNG plant having a capacity less than 2 MTPA can be integrated with a main LNG plant having a capacity of at least 4 MTPA such that end flash gas and boil off gas from the main LNG plant can be liquefied by the small scale LNG plant as incremental LNG. According to WO201576975 the production capacity of the integrated system can be improved by increasing the temperature of the gas stream exiting the main cryogenic heat exchanger of the main LNG plant between 5°C and 30°C as compared with the design temperature.

WO2006009646 is related to hydrocarbon fluid processing plants, methods of designing hydrocarbon fluid processing plants, methods of operating hydrocarbon fluid processing plants, and methods of producing hydrocarbon fluids using

hydrocarbon fluid processing plants. More particularly, some embodiments of the invention are related to natural gas liquefaction plants, methods of designing natural gas liquefaction plants, methods of operating natural gas liquefaction plants and methods of producing LNG using natural gas liquefaction plants. One embodiment of the invention includes a hydrocarbon fluid processing plant including a plurality of process unit module types, the plurality of process unit module types including at least a first process unit module type including one or more first process unit modules and a second process unit module type including two or more integrated second process unit modules wherein at least one of the first process unit modules and at least one of the second process unit modules are sized at their respective substantially maximum processing efficiency.

SUMMARY OF THE INVENTION

It is an aim to provide a more efficient LNG plant.

In one aspect the present invention is directed to a liquid natural gas plant for producing liquefied natural gas from a contaminated natural gas feed stream, the liquid natural gas plant comprising two or more parallel treatment and liquefaction trains arranged in process portions of the contaminated natural gas feed stream in parallel, the treatment and liquefaction trains each comprising:

- an inlet for receiving a portion of the contaminated natural gas feed stream,
- a gas treatment stage for removing contaminants from the respective portion of the contaminated natural gas feed stream) thereby generating a cleaned natural gas stream,

- a cooling stage arranged to receive the cleaned natural gas stream from the gas treatment stage for cooling at least part of the cleaned natural gas stream , wherein the cooling stage comprises an NGL-extraction unit for extracting natural gas liquids , thereby generating a light natural gas stream to be at least partially further cooled by the cooling stage to be at least partially liquefied and

- an outlet for discharging liquefied natural gas,

wherein the liquid natural gas plant comprises at least one additional liquefaction train, the additional liquefaction train comprising:

- an inlet for receiving an additional feed stream,

- an additional cooling stage arranged to receive the additional feed stream for cooling the additional feed stream thereby generating additional liquefied natural gas, and

- an outlet for discharging the additional liquefied natural gas,

5 wherein the additional feed stream comprises two or more side streams taken from the respective light natural gas streams of the two or more parallel treatment and liquefaction trains.

The liquid natural gas plant as defined above also encompasses liquid natural gas plants comprising more than one additional liquefaction train.

10 NGL-extraction unit for extracting natural gas liquids may be performed on any suitable natural gas stream in the cooling stage. According to an embodiment, the cooling stage comprises a first cooling unit, arranged to generate a pre-cooled cleaned natural gas stream and a second cooling unit arranged to generate a further cooled stream. NGL-extraction unit for extracting natural gas liquids may be performed on the pre-cooled cleaned natural gas stream.

15 The inlet of the additional liquefaction train is directly or indirectly in fluid connection with conduits in the respective treatment and liquefaction trains which in use carry the respective light natural gas streams. Furthermore, the inlet of the additional liquefaction train is directly or indirectly in fluid connection with conduits in the respective treatment and liquefaction trains carrying any further streams to be comprised by the additional feed stream.

20 The additional feed stream may comprise further streams, including one or more side streams of natural gas taken downstream from the inlet of the respective treatment and liquefaction trains, such as an end flash stream, a boil-off gas stream (taken from one or more LNG storage tanks), the cleaned natural gas stream. The gas treatment stage may comprise one or more gas treatment units (as explained in more detail below). The additional feed stream may further optionally comprise one or more side streams taken from intermediate partially cleaned natural gas streams in between respective gas treatment units.

30 Additionally, or alternatively, the additional feed stream may comprise further streams obtained from a fractionation unit provided to receive and fractionate the natural gas liquids obtained from the NGL-extraction unit. The further stream may in particular be at least a portion of one or more methane enriched streams generated by

respective fractionation units and/or at least a portion of one or more ethane enriched streams generated by respective fractionation units.

Depending on the composition of the additional feed stream, the additional liquefaction train may comprise some gas treatment units and may comprise a NGL-extraction unit.

However, according to an embodiment, at least 30 mol% of the additional feed stream is formed from the respective light natural gas streams generated by the NGL-extraction units. According to a preferred embodiment at least 50 mol%, or at least 75 mol% of the additional feed stream, e.g. 100 mol%, is formed from the respective light natural gas streams generated by the NGL-extraction units. The additional feed stream may only be formed from the respective light natural gas streams. The light natural gas stream generated by the NGL-extraction unit are clean, lean and at a relatively high pressure, so do not require any further gas treatment units and need no or relatively little compression. The more of the additional feed stream is formed by the respective light natural gas streams, the less compression and gas treatment is needed with respect to the additional liquefaction train.

The additional liquefaction train preferably doesn't comprise a NGL-extraction unit, as the additional feed stream, at least partially and preferably for at least 30 mol%, at least 50 mol% or at least 75mol% already passed through a NGL-extraction unit. According to an embodiment, the additional liquefaction train comprises a relatively small NGL-extraction unit only. The additional liquefaction train requires a relatively small gas treatment stage with only a subset of the gas treatment units of the treatment and liquefaction train and preferably doesn't comprise a gas treatment stage as the additional feed stream is already cleaned. Therefore, the additional liquefaction train requires less hardware and is relatively cheap, both in terms of capital investment costs as well as in operational costs.

By combining streams from two or more parallel treatment and liquefaction trains, the additional liquefaction train can be given a considerable size to benefit from economy of scale.

The respective light natural gas streams of the one or more parallel treatment and liquefaction trains may be referred to as C₁-enriched stream or C₂⁺-depleted streams. The respective light natural gas streams may for instance be obtained from the vapour phase of the reflux vessel of a scrub column, in which case the light

natural gas streams may be at a temperature in the range of minus 40°C – minus 50°C, e.g. minus 45°C, and at a pressure in the range of 40 – 55 bara. Side streams taken from these light natural gas stream to be comprised in the additional feed stream can be passed to the additional liquefaction train directly, i.e. without recompression.

The light natural gas streams may also be heat integrated with a first or pre-cooling unit to recover at least some of the cold present in these streams before obtaining a side stream. In such an embodiment, the side streams taken from the light natural gas streams after cold recovery may be at a temperature in the range of +10°C – +20°C, e.g. +15°C, and at a pressure in the range of 40 – 55 bara.

Preferably, the respective light natural gas streams are heat-integrated with pre-cool step, especially when a collecting and compression unit is provided (collecting and compression unit will be explained in more detail below).

The side streams taken from the respective light natural gas streams have a relatively high pressure related to the pressure of the contaminated natural gas feed stream and/or the cleaned natural gas stream (30-100 bar) which can be fed into the additional liquefaction train, without recompression or with moderate recompression only. In certain embodiments, the pressure of the additional feed stream is selected higher (e.g. 10 or 20 bar higher) than the pressure of the contaminated natural gas feed stream to facilitate efficient cooling and liquefaction, which higher pressure can be obtained at relatively low costs given the relatively high pressure of at least some of the streams comprised by the additional feed stream.

In another aspect there is provided a method of retrofitting an existing liquid natural gas plant to increase the liquefied natural gas production capacity thereof, wherein the existing liquid natural gas plant comprises two or more parallel treatment and liquefaction trains for producing liquefied natural gas from a contaminated natural gas feed stream, wherein the two or more parallel treatment and liquefaction trains are arranged to process portions of the contaminated natural gas feed stream in parallel and are each arranged to:

- receive a portion of a contaminated natural gas feed stream,
- remove contaminants from the respective portion of the contaminated natural gas feed stream thereby generating a cleaned natural gas stream,

- cool at least part of the cleaned natural gas stream and extract natural gas liquids, thereby generating a light natural gas stream to be at least partially further cooled by the cooling stage ,

wherein the method of retrofitting comprises

5 - providing an additional liquefaction train, the additional liquefaction train comprising an additional cooling stage arranged to receive and liquefy an additional feed stream to generate additional liquefied natural gas,

10 - fluidly connecting the additional liquefaction train to two or more of the light natural gas streams of two or more of the treatment and liquefaction trains to obtain side streams of the two or more light natural gas streams to be comprised in the additional feed stream, thereby creating a retrofitted liquid natural gas plant.

15 The method may further comprise fluidly connecting the additional liquefaction train to one or more further streams (as described above), including side streams taken downstream from the inlet of the treatment and liquefaction trains, such as from an end flash stream, a boil-off gas stream (taken from one or more LNG storage tanks, the cleaned natural gas stream, an intermediate partially cleaned natural gas streams in between respective gas treatment units and side streams obtained from a fractionation unit provided to receive and fractionate the natural gas liquids obtained from the NGL-extraction unit (e.g. side streams from one or more methane enriched streams and/or one or more ethane enriched streams).

20 The additional liquefaction train may be as described above. The additional liquefaction train may preferably not comprise a NGL-extraction unit, as the additional feed stream already passed through a NGL-extraction unit. The additional liquefaction train may also not comprise a gas treatment stage as the additional feed stream is already cleaned.

25 The method may further comprise debottlenecking the existing liquid natural gas plant, for instance by replacing or maintaining parts of the existing LNG plant, in particular upstream of the position where natural gas liquids are extracted. Debottlenecking means improving the design throughput of the existing liquid natural gas plant by increasing the design throughput of the most constraining part of the liquid natural gas plant.

30 The method of retrofitting is in particular advantageous in situations in which the capacity of the warm ends, i.e. the pre-treatment unit (described in more detail

below), the gas treatment stage, the NGL extraction unit were designed for a richer and more contaminated gas composition than actually experienced, thereby resulting in spare ullage in the warm ends of the treatment and liquefaction trains, while the cold end, i.e. the equipment downstream of the NGL extraction unit, are already working at or close to their design capacity.

Furthermore, this method is in particular advantageous when the existing treatment and liquefaction trains are constrained by the available gas turbine power output, limiting the available refrigeration capacity.

According to a further aspect there is provided a method of operating a (retrofitted) liquid natural gas plant as described above, wherein the method comprises

- operating the two or more parallel treatment and liquefaction trains whereby operating the two or more parallel treatment and liquefaction trains comprises receiving respective portions of the contaminated natural gas feed streams by the two or more parallel treatment and liquefaction trains at a feed pressure and

- operating the additional liquefaction train, whereby operating the additional liquefaction train comprises providing an additional feed stream comprising two or more light natural gas streams taken from the two or more parallel treatment and liquefaction trains (A, B), wherein the additional feed stream is provided at an additional feed pressure, being at least 10 bar above the feed pressure.

Similar to above, the additional feed stream may comprise one or more further streams, including side streams taken downstream from the inlet of the treatment and liquefaction trains, such as from an end flash stream, a boil-off gas stream (taken from one or more LNG storage tanks), the cleaned natural gas stream, an intermediate partially cleaned natural gas streams in between respective gas treatment units and side streams obtained from a fractionation unit provided to receive and fractionate the natural gas liquids obtained from the NGL-extraction unit (e.g. side streams from one or more methane enriched streams and/or one or more ethane enriched streams).

Because for the additional liquefaction train, which doesn't comprise NGL-extraction, there are no pressure limitations to take into account associated with the NGL-extraction. The additional feed pressure may therefore be selected higher than the feed pressure to contribute to efficient cooling and liquefaction. The additional

feed pressure may even be at least 20 bar above the feed pressure. The additional feed pressure may be above 50 bara, or even may be above 60 bara (bara = bar absolute).

5 BRIEF DESCRIPTION OF THE DRAWINGS

The drawings depict one or more implementations in according with the present teachings, by way of example only, not by way of limitation. In the figures, like reference numerals refer to the same or similar elements. Furthermore, a single reference number will be used to identify a conduit or line as well as the stream
10 conveyed by that line.

Figure 1 is a schematic illustration of an embodiment.

DETAILED DESCRIPTION OF THE INVENTION

The following examples of certain aspects of some embodiments are given to
15 facilitate a better understanding of the present invention. In no way should these examples be read to limit, or define, the scope of the invention.

There is provided a liquid natural gas plant comprising a plurality of liquefaction trains, of which at least one train, referred to as an additional liquefaction train, liquefies gas streams received from the other trains (referred to as
20 treating and liquefaction trains). The additional liquefaction train is preferably added to an existing plant as retrofit.

In existing plant designs, i.e. plants not comprising an additional liquefaction train as described here, typically fuel is obtained from gas streams obtained from the treatment and liquefaction trains, such as portions of the end flash gas and the
25 overhead of the scrub column used for NGL-extraction, which are relatively lean and clean.

Now provided is a liquid natural gas plant in which fuel is mainly obtained from the natural gas feed stream upstream of the cooling and gas treatment units. The relatively lean and clean gas streams mentioned above are now fed to the additional
30 liquefaction train as additional feed stream.

It is recognized that the treatment required for fuel gas, i.e. for fuel gas fed to gas turbines, boilers, LNG plant furnaces) are less stringent than the requirements for LNG. For example, for fuel gas, CO₂ removal is less stringent, heavy hydrocarbon

removal is less stringent, H₂S removal is less stringent, water removal is less stringent and mercury removal is less stringent. The treatment requirements for making the contaminated natural gas feed stream suitable for fuel, may comprise some sort of hydrate formation control (i.e. pre-heating, dew-pointing), pressure control and possibly superheating, but over-all requires less hardware than gas treatment to meet LNG specs.

It is therefore recognized that the relatively clean and lean gas streams can more efficiently be liquefied to produce additional LNG, than used as fuel stream.

The additional liquefaction train can advantageously be added to existing liquid natural gas plants comprising two or more treatment and liquefaction trains, in particular in situations wherein there is overcapacity available upstream in the NGL extraction unit and upstream thereof.

According to WO201576975 the temperature of the main cryogenic heat exchanger is increased to ensure sufficient production of end flash gas and boil off gas to feed the small scale LNG plant. This approach is disadvantageous, as it depends on the additional capacity available in the main cryogenic heat exchanger. Also, changing the temperature could take the operating parameters outside the original design window of the main cryogenic heat exchanger, thereby resulting in a less efficient operation. According to the current embodiments, there is no need to change the temperature of the main cryogenic heat exchanger.

The embodiments provided here allow to operate the LNG plant including the additional liquefaction train, without such a need of increase of the temperature.

Instead of increasing the temperature of the main cryogenic heat exchanger, or more generally said: of the cold end of the train, different measures are suggested to ensure a sufficiently large additional feed stream to benefit from the economy of scale. One of these measures is to take fuel gas from another location in the plant, i.e. a position upstream of the second cooling unit (see detailed description below, also known as the main cryogenic heat exchanger), thereby allowing to use more clean and lean gas from the treatment and liquefaction trains to provide to the additional liquefaction train.

With reference to Fig. 1, there is provided a liquid natural gas plant (1) for producing liquefied natural gas from a contaminated natural gas feed stream (10). The contaminated natural gas feed stream 10 may originate from a pre-treatment unit

2, which is arranged to receive one or more natural gas streams 30 from a source or well and discharge a contaminated natural gas feed stream 10 having a well-defined constant pressure, flow rate and composition. Therefore, the pre-treatment unit 2 may be equipped with a slug catcher, pressure control devices, stabilizers and metering equipment. The slug catcher and the stabilizer are provided to remove heavier liquids (condensates).

The liquid natural gas plant comprises two or more parallel treatment and liquefaction trains A, B. According to an embodiment, the liquid natural gas plant 1 comprises three or more parallel treatment and liquefaction trains, for instance four or six parallel treatment and liquefaction trains. The term parallel is used to indicate that the trains are arranged to process portions of the contaminated natural gas feed stream in parallel. There may however be integration between the parallel treatment and liquefaction trains A, B, for instance by having shared refrigerant loops, shared utility functionality, shared refrigerant make-up facilities.

The respective treatment and liquefaction trains A, B comprise an inlet 11 for receiving a portion of the contaminated natural gas feed stream 10', 10''. The inlet 11 may be in fluid communication with the pre-treatment unit 2 described above.

The respective treatment and liquefaction trains A, B may further comprise a gas treatment stage 12. The gas treatment stage is arranged to receive the respective portion 10', 10'' of the contaminated natural gas feed stream 10 and remove certain contaminants therefrom. The gas treatment stage 12 may comprise one or more of the following gas treatment units:

- acid gas removal unit (AGRU) to remove acid components, CO₂ and/or H₂S, the acid gas removal unit comprising equipment for separation purposes, such as an absorption column, a regenerator column including reboilers, condensers and other heat exchangers, wherein the absorption column and regenerator column comprise internals, e.g. trays or packing (structured/random),
- dehydration unit to remove H₂O, and
- mercury removal unit to remove mercury, and

The acid gas removal unit (AGRU) may also remove aromatic components (co-absorption), to help achieving benzene/ aromatics specifications for liquefaction.

The gas treatment stages 12 comprise an outlet for discharging a cleaned natural gas stream 13. The gas treatment stages 12 may also comprise one or more outlets for respective contaminant streams 36. The respective treatment and liquefaction trains A, B comprise a cooling stage 14 in fluid connection with the outlet of the gas treatment stage 12 to receive the cleaned natural gas stream 13.

The cooling stage 14 is equipped to cool and optionally liquefy at least part of the cleaned natural gas stream 13 received. The cooling stage 14 may comprise any suitable cooling process, such as Single Mixed Refrigerant (SMR) process, Double Mixed Refrigerant (DMR) process, Cascade process, C3MR process, Liquefin™ process as well as expansion based cooling processes. It will be understood that any suitable cooling process may be applied. The parallel treatment and liquefaction train A, B do not necessarily comprise the same cooling process.

By way of example, Figure 1 schematically shows a cooling process comprising a first cooling unit 15, e.g. using a first refrigerant, and a second cooling unit 17, using a second refrigerant. The first refrigerant may be a first mixed refrigerant and the second refrigerant may be a second mixed refrigerant (DMR process). Alternatively, the first refrigerant may be a single component refrigerant (typically propane) and the second refrigerant may be a second mixed refrigerant (SMR process).

Depending on the cooling process and the operating parameters, the cooling stage 14 cools and liquefies at least part of the cleaned natural gas stream 13, or only cools at least part of the cleaned natural gas stream 13, while the phase transition to liquid takes place downstream thereof, e.g. in an end flash unit (described below).

The first cooling unit 15 is arranged to generate a pre-cooled cleaned natural gas stream 151. The second cooling unit 17 is arranged to generate a further cooled stream 171 (being at an operating temperature). The further cooled stream may be substantially liquid (i.e. more than 99 mol% liquid) at the outlet pressure of the second cooling unit 17 (main cryogenic heat exchanger (MCHE)). In treatment and liquefaction train(s) A, including an end-flash unit 18 (as will be described in more detail below), the conditions of the further cooled stream 171' are selected such to produce a liquefied natural gas stream 184 and end flash stream 182 by means of reducing pressure and separation of liquid and vapor phases (described in more detail below). In treatment and liquefaction trains(s) B (a train not comprising an end-flash

unit), the conditions of the further cooled stream 171'' are selected such to produce a liquefied natural gas stream 186. The liquefied natural gas stream 186 is substantially liquid. Herein, a vapor phase may be separated from the liquefied natural gas stream 186 in the LNG storage tank 100. Such vapor is commonly referred to as boil-off gas (BOG). This process may be referred to as flash-in-tank. Further cooled stream 171'' may be a sub-cooled liquid before pressure let down and may typically contain, for instance, about 1 – 3 mol% vapour after pressure let down,. This vapour will be separated, for instance, in the LNG storage tank 100.

It will be understood that many variations exist, which variations typically are the amount of vapor generated and the location where vapor is generated (in LNG storage tank 100 or in end flash unit 18).

Although schematically shown as separate blocks, it will be understood that the first and second cooling units 15, 17 may be integrated. For instance, the second (mixed) refrigerant may be passed through the first cooling unit 15 to be pre-cooled by the first (mixed) refrigerant.

According to the embodiments, the cooling stage 14 comprises a NGL-extraction unit 16 (also known as a NGL removal unit) for extracting natural gas liquids 161 from the cleaned natural gas stream 13. Natural Gas Liquids (NGLs) are hydrocarbon molecules having two or more carbon atoms (C_2^+ -molecules), such as ethane, propane etc..

According to the embodiment schematically depicted in Fig. 1, the NGL-extraction unit 16 is positioned in between the first and second cooling units 15, 17. The NGL extraction unit 16 is therefore arranged to receive the pre-cooled cleaned natural gas stream 151 from the first cooling unit 15. However, other line-ups may be conceivable, for instance depending on the cooling process and gas composition.

The NGL-extraction unit 16 may be a scrub column or any other suitable separator, including a flash vessel. The appropriate NGL-extraction unit 16 depends on the liquid content of the feed gas. For instance, pipeline gas typically contains little NGLs, while associated gas typically contains high amounts of NGLs.

The NGL-extraction unit 16 discharges a natural gas liquid stream 161, which may also be referred to as a C_2^+ -enriched stream 161. The term C_2^+ -enriched is used to indicate that the stream is enriched in C_2^+ molecules compared to the stream

received by the NGL extraction unit 16, in this embodiment stream pre-cooled cleaned natural gas stream 151.

The natural gas liquid stream 161 may be passed on to a fractionation unit, comprising a fractionation column or series of fractionation columns (de-methanizer, de-ethanizer, de-propanizer, etc.), to further separate the components of the natural gas liquid stream 161. The fractionation unit, in use, may generate a methane enriched stream and an ethane enriched stream. The methane enriched stream is enriched in methane compared to the natural gas liquid stream 161. The ethane enriched stream is enriched in ethane compared to the natural gas liquid stream 161.

Some components may be stored separately for separate sale or refrigerant make-up; other components may be fed back to the cooling stage 14, e.g. methane that came with the natural gas liquid stream 161.

According to an embodiment, the additional feed stream may comprise a further stream comprising at least a portion of the one or more methane enriched streams generated by the respective fractionation units of the respective treatment and liquefaction trains (A, B).

According to an embodiment, the additional feed stream may comprise a further stream comprising at least a portion of the one or more ethane enriched streams generated by the respective fractionation units of the respective treatment and liquefaction trains (A, B).

Advantageously, the methane enriched streams and the ethane enriched streams are at a substantial pressure, typically in the range of 20 – 30 bara, e.g. 25 bara, so need relatively little compression for being fed to the additional liquefaction train C.

The NGL-extraction unit 16 further discharges a light natural gas stream 162, in fact being the stream received by the NGL-extraction unit 16 without the natural gas liquid stream 161, which light natural gas stream 162 is at least partially to be further cooled by the second cooling unit 17 and to be at least partially liquefied to generate liquefied natural gas 181. The light natural gas stream 162 may also be referred to as C₁-enriched stream 162.

The term C₁-enriched is used to indicate that the stream is enriched in C₁ molecules (methane) compared to the stream received by the NGL extraction unit 16, in this embodiment stream pre-cooled cleaned natural gas stream 151.

The respective treatment and liquefaction trains A, B comprise an outlet 181 for discharging liquefied natural gas. According to the embodiment schematically depicted in Fig. 1, the liquefied natural gas streams 181 discharged by the outlets 181 are collected in a LNG storage tank 100. However, it will be understood that more than one LNG storage tank 100 may be present, and not all trains are necessarily connected to all LNG storage tanks 100.

The liquid natural gas plant 1 comprises an additional liquefaction train C.

The additional liquefaction train C can be added as retrofit to an existing LNG plant 1, or can be part of the original design of a LNG plant. Retrofitting may in particular be advantageous in situations in which there is overcapacity in the warm end, i.e. in the NGL-extraction unit 16 and upstream thereof, which may for instance be the case when there is a change in the composition of the feed gas, e.g. less CO₂ content, or as a result of (partial) replacement of the equipment for separation purposes of the acid gas removal unit (as described above) and/or retrofitting/expanding other equipment of the acid gas removal unit, such as heat exchangers, allowing a higher throughput through the gas treatment stage 12. It will be understood that replacement of the equipment for separation purposes of the acid gas removal unit, in particular a replacement of internals of the absorption column, and/or replacement/expansion of smaller equipment is a relatively cost-efficient way to increase the throughput of the gas treatment stage 12, in case the acid gas removal unit is the constraining part of the gas treatment stage 12.

Also, retrofitting may be advantageous in case the existing LNG plant was originally oversized.

It is noted that the additional liquefaction train C preferably does not comprise gas treatment, i.e. does not comprise an acid gas removal unit, dehydration unit, mercury removal unit and co-absorption unit, and the additional liquefaction train further doesn't comprise NGL-extraction.

According to an embodiment, the additional liquefaction train C comprises less gas treatment units than the treatment and liquefaction trains A, B. For instance, in case the treatment and liquefaction trains A, B comprise four gas treatment units, e.g. an acid gas removal unit (AGRU), a dehydration unit, a mercury removal unit, and a co-absorption unit, while the additional liquefaction train comprises no more than a subset thereof (three or less gas treatment units).

The additional liquefaction train comprises an additional cooling stage 214 arranged to receive and liquefy an additional feed stream 210 thereby generating additional liquefied natural gas. The additional cooling stage C may again use any suitable cooling process, such as the examples provided above, and may be similar or
5 different to the cooling processes comprised by the treatment and liquefaction trains A, B.

According to the embodiment depicted in Fig. 1, the additional liquefaction train C comprises a similar cooling stage as the treatment and liquefaction trains A, B described above, i.e. comprises a first cooling unit 215 is arranged to generate a pre-cooled natural gas stream 2151 and a second cooling unit 217 is arranged to generate
10 a further cooled stream 2171. The second cooling unit 217 is arranged to receive the pre-cooled cleaned natural gas stream 2151 from the first cooling unit 215 directly.

The additional liquefaction train C optionally comprises an end-flash unit 218, which is arranged to receive the further cooled stream 2171 and discharge a flash
15 stream 282 and a liquid natural gas stream 284 via outlet 281.

The additional liquefaction train C receives an additional feed stream 210 which comprises at least two side streams 163 taken from the respective light natural gas streams 162 discharged by the NGL-extraction units 16 of the one or more parallel treatment and liquefaction trains (A, B). The at least two side streams 163 are
20 substantially gaseous. Depending on the pressure of the at least two side streams 163, the side streams 163 may be passed through a collecting and compression unit 202, described in more detail below. The second cooling unit 217 can directly receive the pre-cooled cleaned natural gas stream 2151 from the first cooling unit 215, because NGL 161 has already been removed from the additional feed stream 210 by the
25 NGL extraction units 16 of the respective treatment and liquefaction trains A, B.

The additional liquefaction train C may be a stand-alone train, i.e. being separate from the treatment and liquefaction trains A, B. However, the additional liquefaction train C may also be integrated with the one or more treatment and liquefaction trains A, B, for instance, by sharing refrigerant make-up facilities, utilities, etc.

30 According to an embodiment, one or more of the parallel treatment and liquefaction trains (A) comprise an end flash unit 18 arranged to receive and flash at least part of the further cooled stream 171 to generate an end flash stream 182 and a liquefied natural gas stream 184. The end flash stream 182 is substantially gaseous.

The liquefied natural gas stream 184 is substantially liquid. Herein, the additional feed stream 210 may further comprise at least a portion of the one or more flash streams 182 generated by the respective end flash units 18 of the one or more of the parallel treatment and liquefaction trains (A).

5 The end-flash unit 18 may be positioned downstream of the cooling stage 14 and arranged to receive (part of) the further cooled stream 171.

Fig. 1 shows one train with end flash unit 18 and one train without end flash unit 18, but it will be understood that any number of the parallel treatment and liquefaction trains present may comprise an end flash unit 18, including none and all.

10 In addition to only using side streams 163 taken from the respective light natural gas streams 162 from the NGL extraction unit 16, end-flash gas 182 may be used in addition. In use, any suitable portion of the end flash stream 182 may be used, ranging from 0% to 100%. The portion of the end flash stream 182 not fed to the additional liquefaction train C, may be used for fuel or may be flared.

15 According to an embodiment, the entire flash streams 182 of one or more treatment and liquefaction trains A comprising an end flash unit 18 are comprised by the additional feed stream. According to an embodiment, the entire flash streams 182 of all the treatment and liquefaction trains A comprising an end flash unit 18 are comprised by the additional feed stream.

20 As the flash streams 182 are already relatively clean and lean, the additional liquefaction train C doesn't require (all of the) a gas treatment stage or NGL-extraction unit.

 According to an embodiment, the flash streams 182 are first passed through the respective cooling stages of the treatment and liquefaction trains A from which they
25 are obtained for cold-recovery purposes before being (partially) passed on to the additional liquefaction train C.

 The different streams to be comprised in the additional feed stream 210 may not all be at the same pressure and may not (all) be at a suitable pressure. This is in particular the case when the additional feed stream 210 also comprises (a portion of)
30 flash streams 182, as flash streams are typically at a relatively low pressure, such as close to ambient.

 According to an embodiment the liquid natural gas plant 1 comprises a collecting and compression unit 202, comprising a plurality of inlets to receive the

respective streams to be comprised by the additional feed stream 210. The collecting and compression unit 202 is arranged to pressurize and combine the different streams to form and discharge the additional feed stream.

5 The collecting and compression unit 202 may comprise a single or multistage compressor 203, optionally with inter and/or after-coolers (not shown), to compress the streams to be comprised by the additional feed stream to a predetermined additional feed pressure. The compressor 203 may have one or more inlets allowing inflow of streams with different pressures.

10 In a further embodiment, the driver of the compressor 203 is mechanically or electrically connected to the driver of one or more refrigerant compressors in train C. The additional liquefaction train C may comprise one or more refrigerant compressors arranged to compress refrigerant, being part of the refrigeration loop, as will be understood by a skilled person. Combination of compressors to a driver (less drivers than compressors) enables a better matching of driver(s) power to
15 compressor(s) power, especially if the drivers are gas turbines, thereby benefitting of the economy of scale of less but larger drivers, for the same capacity of additional liquefaction train C.

In a further embodiment, the additional feed pressure (stream 210) is selected such that the compressor power for compressor 203 and the refrigerant compressor
20 power for additional cooling stage 214 are selected to further match driver and compressor power.

The additional feed pressure may be selected substantially higher than the feed pressure of the contaminated natural gas feed stream 10 for the treatment and liquefaction trains A, B. Since preferably no NGL-extraction is required in the
25 additional train C, there are no pressure limitations/considerations to take into account associated with the NGL-extraction. NGL-extraction typically takes place at a predetermined pressure, typically in the range of 30 – 60 bara, e.g. 50 bara, depending on the optimal conditions for performing NGL extraction for the particular composition of the stream. NGL-extraction is preferably done at a
30 relatively low pressure, while liquefaction can typically be done more efficiently at a relatively higher pressure. These two effects need to be balanced. The absence of NGL-extraction in the additional liquefaction train C eliminates this balancing and allows for a more optimal pressure for liquefaction.

A relatively high pressure in the NGL-extraction units of the treatment and liquefaction trains A, B minimizes the need for (re-)compression of the two or more side streams (163) taken from the respective light natural gas streams (162) to be comprised in the additional feed stream.

5 According to an embodiment, the additional feed pressure of the additional feed stream 210 may be more than 10 bar higher than the feed pressure of the contaminated natural gas feed stream 10, more preferably even more than 20 bar higher. The higher additional feed pressure contributes to more efficient cooling and liquefaction of the additional feed stream.

10 The one or more compressors may be suitable to compress the streams to be comprised by the additional feed stream to a pressure that is more than 10 bar or even more than 20 bar above a feed pressure at which the contaminated natural gas feed stream (10, 10', 10'') is received by the parallel treatment and liquefaction trains (A, B).

15 In embodiments in which the additional feed stream 210 comprises at least a portion of one or more flash streams 182, the additional feed 210 stream may be relatively rich in nitrogen.

 According to an embodiment the liquid natural gas plant comprises a nitrogen removal stage (not shown), the nitrogen removal stage being arranged to receive one
20 or more streams to be comprised by the additional feed stream and discharge one or more nitrogen depleted streams.

 The nitrogen removal stage (also referred to as nitrogen removal unit) may be incorporated in the additional liquefaction train C, maybe incorporated in the collecting and compression unit 202 or may be incorporated in between the end flash
25 unit 18 and upstream of the collecting and compression unit 202/additional liquefaction train C. In the latter embodiment, there is preferably a single nitrogen removal stage provided to process all the end flash streams to be comprised by the additional feed stream 210. The nitrogen removal stage comprises an outlet arranged to discharge the one or more nitrogen depleted streams, the outlet being in fluid
30 communication with the collecting and compression unit 202 or with the collecting and compression unit 202.

 However, the use of an additional liquefaction train as described may in particular be suitable in situations wherein the contaminated natural gas feed stream

10 has a low nitrogen content, which would eliminate the requirement for a nitrogen removal stage as additional treatment step, i.e. would eliminate the requirement for a nitrogen removal stage to be comprised by the additional liquefaction train C or positioned upstream thereof.

5 According to an embodiment, the natural gas feed stream 10 preferably has a nitrogen content of less than 1,0 mol% or less than 0.5 mol%.

 More specifically, the nitrogen content of the portion of the contaminated natural gas feed stream 10' provided to treatment and liquefaction train A comprising an end flash unit 18 is preferably less than 0.5 mol%, while the nitrogen content of the portion of the contaminated natural gas feed stream 10'' provided to treatment and liquefaction train B, not comprising an end flash unit 18, is preferably less than 1,0 mol%.

 Fig. 1 further shows a fuel unit 300. The fuel unit 300 is depicted schematically and comprises a fuel inlet 301 to receive a fuel stream, comprising a side stream 32 of the contaminated natural gas feed stream 10. The fuel unit 300 is arranged to burn the fuel stream to generate power (electricity) to provide power or energy (heat) to LNG plant 1, including in particular gas turbine drivers for refrigerant compressors, gas turbine generators for electrical power generation, fuel for the heat transfer furnaces/steam boilers, flare pilots and to supply fuel for heat demand, in particular gas treatment stage 12 may require heat. In Fig. 1 the parts of the liquid natural gas plant requiring power from the fuel unit 300 are schematically indicated by power consumers 302.

 The fuel stream comprises at least a portion 32 of the contaminated natural gas feed stream 10. Preferably, at least 50% of the fuel stream is formed by the fuel side-stream 32 of the contaminated natural gas feed stream 10, a portion 34 of the end flash stream 182, and/or a portion of the cleaned natural gas stream 13.

 According to an embodiment, there is provided a method of retrofitting a liquid natural gas plant comprising at least two or more first liquefaction trains A, B arranged in parallel with an additional liquefaction train C. After completing the retrofit, the liquid natural gas plant 1 can be operated with a flow rate for the contaminated natural gas feed stream 10 as outputted by the pretreatment unit 2, which can be increased with respect to a flow rate for the contaminated natural gas feed stream 10 prior to the retrofit (i.e. without additional train C).

Preferably the fuel side stream is taken from the contaminated natural gas feed stream 10. However, in situations where the contaminated natural gas feed comprises relatively high amounts of H₂S, the fuel side-stream is preferably taken from the cleaned natural gas stream 13.

5 According to an embodiment, the liquid natural gas plant comprises at least four or more parallel treatment and liquefaction trains (A, B).

 The treatment and liquefaction trains preferably each have a capacity of at least 2 mmtpa, preferably at least 3 mmtpa (mmtpa: million metric tonnes of LNG per year). This way the additional liquefaction train (C) may have a capacity of at least 2
10 mmtpa to benefit from economy of scale.

 Also, in case the additional liquefaction train is added to an existing liquid natural gas plant, having at least four or more, e.g. six, parallel treatment and liquefaction trains with the above mentioned capacity, a sufficiently large additional feed stream can be generated without the need to change the operating parameters of
15 the existing parallel treatment and liquefaction trains.

 According to an embodiment there is provided a method of retrofitting an existing liquid natural gas plant to increase the liquefied natural gas production capacity thereof. The resulting liquid natural gas plant may be referred to as a retrofitted liquid natural gas plant.

20 The existing liquid natural gas plant (1) may comprise two or more parallel treatment and liquefaction trains (A, B) as described above, which are arranged to
- receive a portion of a contaminated natural gas feed stream (10', 10''),
- remove contaminants from the respective portion of the contaminated natural gas feed stream (10', 10'') thereby generating a cleaned natural gas stream (13),
25 - cool at least part of the cleaned natural gas stream (13) and extract natural gas liquids (161) from the cleaned natural gas stream (13), thereby generating a light natural gas stream (162) to be at least partially further cooled by the cooling stage (14).

 The method of retrofitting comprises

30 - providing an additional liquefaction train (C), the additional liquefaction train comprising an additional cooling stage arranged to receive and liquefy an additional feed stream (210) thereby generating additional liquefied natural gas. The additional

liquefaction train may be as described above, i.e. may not comprise NGL-extraction and/or gas treatment.

The method of retrofitting comprises

- fluidly connecting the additional liquefaction train (C) to two or more of the light natural gas streams (162) of two or more of the treatment and liquefaction trains (A, B) to obtain side streams (163) of the two or more light natural gas streams to be comprised in the additional feed stream (210).

In case the existing liquid natural gas plant comprises one or more parallel treatment and liquefaction trains (A) comprising an end flash unit (18) as described above, the method of retrofitting may comprise

- fluidly connecting the additional liquefaction train (C) to one or more of the end flash streams (182) to receive at least a portion thereof to be comprised in the additional feed stream (210).

The method of retrofitting may comprise

- providing a collecting and compression unit (202) comprising a plurality of inlets to receive the respective streams to be comprised by the additional feed stream from the two or more parallel treatment and liquefaction trains (A, B), the collecting and compression unit comprising one or more compressors to compress the streams to be comprised by the additional feed stream to a predetermined additional feed pressure and combine the streams to be comprised by the additional feed stream to form the additional feed stream, the collecting and compression unit (202) further comprising an outlet to discharge the additional feed stream (210),

- fluidly connecting the respective inlets of the collecting and compression unit (202) with the two or more parallel treatment and liquefaction trains (A, B) and fluidly connecting the outlet of the collecting and compression unit (202) with the additional liquefaction train (C).

The respective inlets of the collecting and compression unit are fluidly connected with those streams of the parallel treatment and liquefaction trains from which gas is taken to be comprised in the additional feed stream 210.

- According to an embodiment, the existing liquid natural gas plant comprises a fuel unit (300), the fuel unit (300) being arranged to receive and burn a fuel stream, thereby generating power and/or heat to provide the liquid natural gas plant (1) with energy and/or heat,

wherein the method of retrofitting comprises

- fluidly connecting the fuel unit (300) to receive a side-stream of the contaminated natural gas feed stream (10) or the cleaned natural gas stream (13).

5 The existing liquid natural gas plant may comprise a fluid fuel connection between the fuel unit and the respective parallel treatment and liquefaction trains, e.g. between the fuel unit and end flash streams (182), to provide the fuel unit with fuel. The method of retrofitting may comprise disconnecting this fuel connection. The method of retrofitting may also comprise leaving the existing fuel connection in place, but in use, the flow rate through the existing fuel connection will be
10 significantly reduced compared to prior to the retrofit, typically reduced with more than 50%.

As described above, the treatment and liquefaction trains may comprise a first cooling unit 15 and a second cooling unit 17, the second cooling unit generating a further cooled stream 171 being at an operating temperature, wherein the operating temperature in the treatment and liquefaction trains A, B is substantially equal prior
15 and after retrofitting. The term substantial equal is used here to indicate that the operating temperatures differ less than 4°C, preferably less than 2°C.

Once a retrofitted liquid natural gas plant has been provided, the retrofitted liquid natural gas plant may be operated, wherein the method of operating comprises
20 - receiving the respective portions of the contaminated natural gas feed streams (10', 10'') at a feed pressure and
- pressurizing the additional feed stream to an additional feed pressure, being at least 10 bar above the feed pressure,
- feeding the additional feed stream to the additional liquefaction train (C).

25 According to an embodiment, the additional feed pressure of the additional feed stream 210 may be more than 10 bar higher than the feed pressure of the contaminated natural gas feed stream 10, more preferably even more than 20 bar higher. The higher additional feed pressure contributes to more efficient cooling and liquefaction of the additional feed stream.

30 The present disclosure is not limited to the embodiments as described above and the appended claims. Many modifications are conceivable and features of respective embodiments may be combined.

Additional embodiments

According to a further embodiment, there is provided a liquid natural gas plant (1) for producing liquefied natural gas from a contaminated natural gas feed stream (10), the liquid natural gas plant (1) comprising one or more parallel treatment and liquefaction trains (A, B), wherein the respective treatment and liquefaction trains (A, B) comprise:

- an inlet (11) for receiving a portion of the contaminated natural gas feed stream (10', 10''),
 - a gas treatment stage (12) for removing contaminants from the respective portion of the contaminated natural gas feed stream (10', 10'') thereby generating a cleaned natural gas stream (13),
 - a cooling stage (14) arranged to receive the cleaned natural gas stream (13) from the gas treatment stage (12) for cooling at least part of the cleaned natural gas stream (13), wherein the cooling stage (14) comprises a NGL-extraction unit (16) for extracting natural gas liquids (161), thereby generating a light natural gas stream (162) to be at least partially further cooled by the cooling stage (14) to be at least partially liquefied and
 - an outlet (181) for discharging liquefied natural gas,
- wherein the liquid natural gas plant (1) comprises an additional liquefaction train (C), the additional liquefaction train comprising
- an inlet (211) for receiving an additional feed stream (210),
 - an additional cooling stage (214) arranged to receive the additional feed stream for cooling the additional feed stream (210) thereby generating additional liquefied natural gas, and
 - an outlet (281) for discharging the additional liquefied natural gas (284),
- wherein the additional feed stream (210) comprises one or more side streams (163) taken from the respective light natural gas streams (162) of the one or more parallel treatment and liquefaction trains (A, B).

According to a further embodiment there is provided a method of retrofitting an existing liquid natural gas plant to increase the liquefied natural gas production capacity thereof, wherein the existing liquid natural gas plant (1) comprises one or more parallel treatment and liquefaction trains (A, B) for producing liquefied natural gas from a contaminated natural gas feed stream (10), wherein the one or more parallel treatment and liquefaction trains (A, B) are arranged to

- receive a portion of a contaminated natural gas feed stream (10', 10''),
 - remove contaminants from the respective portion of the contaminated natural gas feed stream (10', 10'') thereby generating a cleaned natural gas stream (13),
 - cool at least part of the cleaned natural gas stream (13) and extract natural gas liquids (161), thereby generating a light natural gas stream (162) to be at least partially further cooled by the cooling stage (14),
- 5
- wherein the method of retrofitting comprises
- providing an additional liquefaction train (C), the additional liquefaction train comprising an additional cooling stage arranged to receive and liquefy an additional
- 10
- feed stream (210) to generate additional liquefied natural gas,
- fluidly connecting the additional liquefaction train (C) to one or more of the light natural gas streams (162) of one or more of the treatment and liquefaction trains (A, B) to obtain side streams (163) of the one or more light natural gas streams to be comprised in the additional feed stream (210), thereby creating a retrofitted liquid
- 15
- natural gas plant.

According to a further embodiment there is provided a method of operating a retrofitted liquid natural gas plant (1) according to the above or being provided according to method or retrofitting provided above, wherein the method comprises

- operating the one or more parallel treatment and liquefaction trains (A, B)
- 20
- whereby operating the one or more parallel treatment and liquefaction trains (A, B) comprises receiving respective portions of the contaminated natural gas feed streams (10', 10'') by the one or more parallel treatment and liquefaction trains (A, B) at a feed pressure and
- operating the additional liquefaction train (C), whereby operating the
- 25
- additional liquefaction train (C) comprises providing an additional feed stream comprising one or more light natural gas streams (163) taken from the one or more parallel treatment and liquefaction trains (A, B), wherein the additional feed stream is provided at an additional feed pressure, being at least 10 bar above the feed pressure.

30

It is recognized that an additional liquefaction train may also be added to a single treatment and liquefaction train. The additional feed stream may comprise any combination of the above disclosed streams taken from the (single) treatment and liquefaction trains, such as end flash.

CLAIMS

1. Liquid natural gas plant (1) for producing liquefied natural gas from a contaminated natural gas feed stream (10), the liquid natural gas plant (1) comprising
5 two or more parallel treatment and liquefaction trains (A, B) arranged in process portions of the contaminated natural gas feed stream (10) in parallel, the treatment and liquefaction trains (A, B) each comprising:
- an inlet (11) for receiving a portion (10', 10'') of the contaminated natural gas feed stream (10),
 - 10 - a gas treatment stage (12) for removing contaminants from the respective portion (10', 10'') of the contaminated natural gas feed stream (10) thereby generating a cleaned natural gas stream (13),
 - a cooling stage (14) arranged to receive the cleaned natural gas stream (13) from the gas treatment stage (12) for cooling at least part of the cleaned natural gas stream (13), wherein the cooling stage (14) comprises a NGL-extraction unit (16) for
15 extracting natural gas liquids (161), thereby generating a light natural gas stream (162) to be at least partially further cooled by the cooling stage (14) to be at least partially liquefied; and
 - an outlet (181) for discharging liquefied natural gas (184, 186),
 - 20 wherein the liquid natural gas plant (1) comprises at least one additional liquefaction train (C), the additional liquefaction train comprising:
 - an inlet (211) for receiving an additional feed stream (210),
 - an additional cooling stage (214) arranged to receive the additional feed stream (210) for cooling the additional feed stream (210) thereby generating
25 additional liquefied natural gas (284), and
 - an outlet (281) for discharging the additional liquefied natural gas (284),
 - wherein the additional feed stream (210) comprises at least two or more side streams (163) taken from the respective light natural gas streams (162) of the two or more parallel treatment and liquefaction trains (A, B).
 - 30
2. Liquid natural gas plant (1) according to claim 1, wherein one or more of the parallel treatment and liquefaction trains (A) comprise an end flash unit (18) arranged to receive and flash at least part of the respective light natural gas streams to

generate an end flash stream (182) and liquefied natural gas (181), wherein the additional feed stream (210) further comprises at least a portion of the one or more flash streams (182) generated by the respective end flash units (18).

- 5 3. Liquid natural gas plant (1) according to any one of claims 1 or 2, wherein the liquid natural gas plant (1) comprises a collecting and compression unit (202), comprising a plurality of inlets to receive the respective streams to be comprised by the additional feed stream (210). The collecting and compression unit (202) is arranged to pressurize and combine the different streams to form and discharge the additional feed stream.
- 10
4. Liquid natural gas plant (1) according to any one of the preceding claims, wherein the liquid natural gas plant comprises a nitrogen removal stage, the nitrogen removal stage being arranged to receive one or more streams to be comprised by the additional feed stream and discharge one or more nitrogen depleted streams.
- 15
5. Liquid natural gas plant (1) according to any one of the preceding claims, wherein the liquid natural gas plant comprises a fuel unit (300) comprising a fuel inlet (301) to receive a fuel stream, the fuel stream comprising a side stream of the contaminated natural gas feed stream (10).
- 20
6. Liquid natural gas plant (1) according to any one of the preceding claims, wherein the liquid natural gas plant (1) comprises at least four or more parallel treatment and liquefaction trains (A, B).
- 25
7. Method of retrofitting an existing liquid natural gas plant to increase the liquefied natural gas production capacity thereof, wherein the existing liquid natural gas plant (1) comprises two or more parallel treatment and liquefaction trains (A, B) for producing liquefied natural gas from a contaminated natural gas feed stream (10), wherein the two or more parallel treatment and liquefaction trains (A, B) are arranged to process portions of the contaminated natural gas feed stream (10) in parallel and are each arranged to:
- 30
- receive a portion (10', 10'') of a contaminated natural gas feed stream (10),

- remove contaminants from the respective portion (10', 10'') of the contaminated natural gas feed stream (10) thereby generating a cleaned natural gas stream (13),

- cool at least part of the cleaned natural gas stream (13) and extract natural gas liquids (161), thereby generating a light natural gas stream (162) to be at least partially further cooled by the cooling stage (14),

wherein the method of retrofitting comprises the steps of:

- providing an additional liquefaction train (C), the additional liquefaction train comprising an additional cooling stage (214) arranged to receive and liquefy an additional feed stream (210) to generate additional liquefied natural gas (284),

- fluidly connecting the additional liquefaction train (C) to two or more of the light natural gas streams (162) of two or more of the treatment and liquefaction trains (A, B) to obtain side streams (163) of the two or more light natural gas streams to be comprised in the additional feed stream (210), thereby creating a retrofitted liquid natural gas plant.

8. Method of retrofitting according to claim 7, wherein the existing liquid natural gas plant comprises one or more parallel treatment and liquefaction trains (A) comprising an end flash unit (18), the method of retrofitting comprising

- fluidly connecting the additional liquefaction train (C) to one or more of the end flash streams (182) to receive at least a portion thereof to be comprised in the additional feed stream (210).

9. Method of retrofitting according to any one of the claims 7 – 8, comprising

- providing a collecting and compression unit (202) comprising a plurality of inlets to receive the respective streams to be comprised by the additional feed stream from the two or more parallel treatment and liquefaction trains (A, B), the collecting and compression unit comprising one or more compressors to compress the streams to be comprised by the additional feed stream to a predetermined additional feed pressure and combine the streams to be comprised by the additional feed stream to form the additional feed stream, the collecting and compression unit (202) further comprising an outlet to discharge the additional feed stream (210),

- fluidly connecting the respective inlets of the collecting and compression unit (202) with the two or more parallel treatment and liquefaction trains (A, B) and fluidly connecting the outlet of the collecting and compression unit (202) with the additional liquefaction train (C).

5

10. Method of retrofitting according to any one of the claims 7 – 9, wherein the existing liquid natural gas plant comprises a fuel unit (300), the fuel unit (300) being arranged to receive and burn a fuel stream, thereby generating power and/or heat to provide the liquid natural gas plant (1) with energy and/or heat,

10

wherein the method of retrofitting comprises the step of:

fluidly connecting the fuel unit (300) to receive a side-stream of the contaminated natural gas feed stream (10) or the cleaned natural gas stream (13).

15

11. Method of operating a liquid natural gas plant (1) according to any one of claims 1 – 6 or being provided according to the method of any one of claims 7 – 10, the method comprising the steps of:

20

- operating the two or more parallel treatment and liquefaction trains (A, B) whereby operating the two or more parallel treatment and liquefaction trains (A, B) comprises receiving respective portions (10', 10'') of the contaminated natural gas feed stream (10) by the two or more parallel treatment and liquefaction trains (A, B) at a feed pressure and processing said portions (10', 10'') of the contaminated natural gas feed stream (10) in parallel, and

25

- operating the additional liquefaction train (C), whereby operating the additional liquefaction train (C) comprises providing an additional feed stream (210) comprising at least two or more light natural gas streams (163) taken from the two or more parallel treatment and liquefaction trains (A, B), wherein the additional feed stream (210) is provided at an additional feed pressure, being at least 10 bar above the feed pressure.

