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(71) Applicant: **SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.**
2596 HR Den Haag (NL)

(72) Inventor: **Mariott, Bruce Michael**
5088 Kuala Lumpur (MY)

(74) Representative: **Zeestraten, Albertus W. J.**
Shell International B.V.,
Intellectual Property Services,
P.O. Box 384
2501 CJ The Hague (NL)

(54) **Method for starting up a plant for the liquefaction of a hydrocarbon stream**

(57) The present invention relates to a method for starting up a plant (1), preferably a new plant, for the liquefaction of a hydrocarbon feed stream (10) such as natural gas, wherein a liquefied hydrocarbon stream (110) that has been liquefied in a different liquefaction plant is used.
At least a part of the liquefied hydrocarbon stream (110) that has been liquefied in a different liquefaction plant may be vaporized (15) and subsequently used as a fuel gas (120) or a commissioning gas in the plant (1).
Further, at least a part of the liquefied hydrocarbon stream (110) that has been liquefied in a different liquefaction plant may be introduced into the plant (1), in particular for cooling down the plant (1).

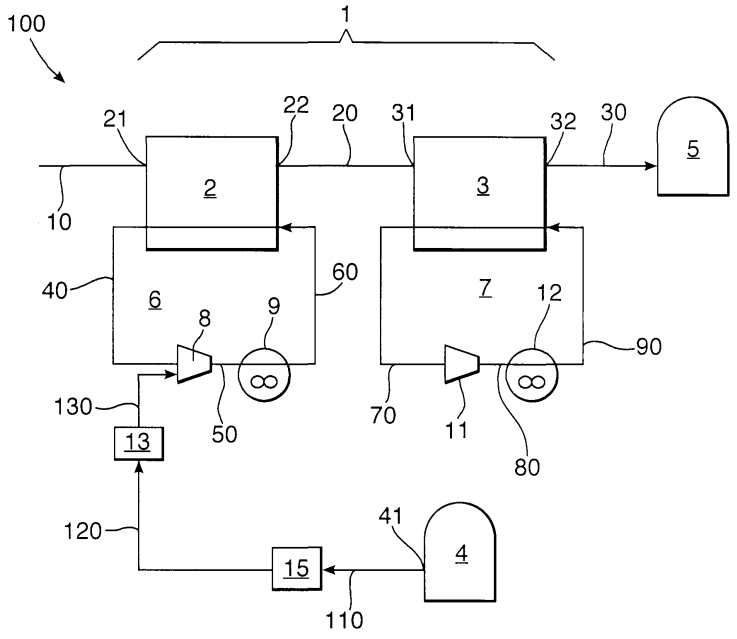

Fig. 1

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Description

[0001] The present invention relates to a method for starting up a plant for the liquefaction of a hydrocarbon stream such as natural gas. The present invention is especially directed to starting up a new plant.

[0002] It is desirable to liquefy a hydrocarbon stream such as natural gas for a number of reasons. As an example, natural gas can be stored and transported over long distances more readily as a liquid than in gaseous form, because it occupies a smaller volume and does not need to be stored at high pressures.

[0003] The starting-up of a plant for the liquefaction of a hydrocarbon stream, such as an LNG (Liquefied Natural Gas) plant may take a considerable amount of time as the various elements need to be purged and cooled down to the desired operating temperatures.

[0004] A known method for starting up a plant for the liquefaction of natural gas is disclosed in the presentation "Passing the Baton Cleanly" by F.W. Richardson, P. Hunter, T. Diocee and J. Fisher, at GasTech 2000, 12-17 November 2000. This presentation discusses the commissioning, start-up and operation of the Atlantic LNG facilities located at Point Fortin in Trinidad.

[0005] A problem of the above known method for starting up the plant is that it takes a considerable amount of time; as can be learned form the above presentation, the starting up of an LNG plant may easily take more than 6 months. The above problem is even more pertinent if no on-spec fuel gas is available.

[0006] A further problem of the above method is that in the process of starting up of the plant fuel gas that is available during the starting up is used for firing a gas turbine for driving one or more compressors in the refrigerant cycles. A disadvantage is that this fuel gas being available during the starting up may not be on-spec for the gas turbine. Furthermore, the gas turbine is only started up after some fuel gas becomes available to the plant, resulting in a significant loss of time.

[0007] It is an object of the invention to minimize one or more of the above problems.

[0008] It is a further object of the present invention to provide an alternative method for starting up a plant for the liquefaction of a hydrocarbon stream, in particular natural gas.

[0009] One or more of the above or other objects are achieved according to the present invention by providing a method for starting up a plant, preferably a new plant, for the liquefaction of a hydrocarbon feed stream such as natural gas, wherein a liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant is used.

[0010] It has surprisingly been found that, by using liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant, a significant gain of time may be achieved.

[0011] A further advantage of the present invention is that the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant may have a more desired composition than the fuel gas that is available during the starting up of the plant.

[0012] An even further advantage of the present invention is that equipment and piping systems being situated at the more downstream side of the plant may be started up at an earlier moment, i.e. well before the finalization of the start-up of the upstream elements of the liquefaction plant and even before any hydrocarbon feed stream to be liquefied is present.

[0013] According to the present invention, the term "starting up" includes the restarting up of an already existing plant as well as the starting up of a new plant. Furthermore, the term "starting up" is not limited to activities performed for cooling down the plant, but also includes the commissioning of a plant, i.e. the activities performed after equipment of the plant has been installed but before the plant is cooled down or before a hydrocarbon feed stream is introduced for actual production of a liquefied hydrocarbon product and fuel gases. This commissioning may e.g. include testing, purging and drying out the various equipment and piping systems. In this respect also reference is made to the activities as mentioned under "Milestones" in the above-mentioned GasTech 2000 article.

[0014] The hydrocarbon feed stream to be liquefied may be any suitable hydrocarbon-containing stream to be liquefied, but is usually a natural gas stream obtained from natural gas or petroleum reservoirs. As an alternative the natural gas stream may also be obtained from another source, also including a synthetic source such as a Fischer-Tropsch process.

[0015] Usually the natural gas stream is comprised substantially of methane. Depending on the source, the natural gas may contain varying amounts of hydrocarbons heavier than methane such as ethane, propane, butanes and pentanes as well as some aromatic hydrocarbons. The natural gas stream may also contain non-hydrocarbons such as H_2O, N_2, CO_2, H_2S and other sulphur compounds, and the like.

[0016] If desired, the feed stream containing the natural gas may be pre-treated before liquefaction. This pre-treatment may comprise removal of undesired components such as CO_2 and H_2S, or other steps such as pre-cooling, pre-pressurizing or the like. As these steps are well known to the person skilled in the art, they are not further discussed here.

[0017] The person skilled in the art will understand that the liquefaction plant to be started up may be one of various line-ups, without being limited to a specific line-up. As the person skilled readily understands how to liquefy a hydrocarbon stream, this is not further discussed here in full detail. The plant may e.g. comprise one or more heat exchangers with respective refrigerant cycles to cool the feed stream in one or more steps; one or more pre-treating units for removing undesired components from the feed stream such as H_2O, N_2, CO_2, H_2S and other sulphur compounds; a so-called NGL (natural gas liq-

uids) extraction unit to remove one or more hydrocarbons heavier than methane such as ethane, propane, butanes and pentanes; storage tanks for the storage of liquefied product; etc.

[0018] Further the person skilled in the art will readily understand that after liquefaction, the liquefied natural gas may be further processed, if desired.

[0019] According to the present invention with "a liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant" is meant that an already existing liquefied hydrocarbon stream is used that has not been liquefied in the plant being started up but that has previously been liquefied in a different liquefaction plant. The liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant may have been produced in a nearby liquefaction train that has already been started up. However, usually the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant will have been produced in a remote location and shipped or otherwise transported to the location where the plant to be started up is located. Thus, the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant is preferably obtained from an offloading LNG carrier vessel.

[0020] The person skilled in the art will understand that the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant may be stored temporarily in a storage tank before it is used in the plant to be started up, e.g. in a storage tank at an LNG import terminal. If desired, the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant may be even be stored temporarily in the storage tank forming part of the plant to be started up (i.e. the storage tank wherein the liquefied hydrocarbon stream produced in the plant to be started up will be stored).

[0021] The liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant may be used in various ways during the starting up of the liquefaction plant.

[0022] According to a first embodiment at least a part of the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant is vaporized and subsequently used as a fuel gas in the plant. The fuel gas may be used e.g. to commission fuel gas systems, for power generation of any gas turbines in the plant, to commission electrical distribution systems, to fire heaters, etc.

[0023] Preferably the fuel gas is used for firing a gas turbine of the plant, in particular for driving a compressor, preferably a compressor forming part of a refrigerant cycle used for cooling at least a part of the hydrocarbon feed stream to be liquefied in the plant being started up.

[0024] According to a second embodiment (which may also be used in combination with the above-mentioned first embodiment), at least a part of the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant is used for providing electric power to the plant.

[0025] Furthermore at least a part of the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant may be vaporized and subsequently used as a commissioning gas in the plant, e.g. in a hydrocarbon purge process train, to dry out a mercury removal bed, to regenerate molecular sieves, to test refrigerant compressors, etc.

[0026] According to a further embodiment, at least a part of the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant is introduced into the plant, in particular for cooling down the plant. To this end the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant may be introduced in e.g. the piping system and equipment of the plant. As an example, the liquefied hydrocarbon that has been liquefied in a different liquefaction plant may be used to cool down the loading system, tanks and associated equipment and an end-flash system. Furthermore, at least a part of the liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant may be heat exchanged against a stream used in the plant to be started up.

[0027] In a further aspect the present invention provides a system for starting up a plant for the liquefaction of a hydrocarbon feed stream such as natural gas, the system at least comprising:

- a plant for the liquefaction of a hydrocarbon feed stream, the plant at least comprising a heat exchanger having an inlet for the feed stream to be cooled and an outlet for a cooled stream, wherein the feed stream can be heat exchanged against a refrigerant being cycled in a refrigerant cycle containing at least a compressor for compressing evaporated refrigerant;
- a storage tank for storing a liquefied hydrocarbon stream produced in the plant; and
- a source of a liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant.

[0028] Preferably the system further comprises one or more of: a vaporizer connected to an outlet of the source for vaporizing at least a part of the liquefied hydrocarbon stream from said source; a gas turbine connected to an outlet of the vaporizer; etc.

[0029] Hereinafter the invention will be further illustrated by the following non-limiting drawing. Herein shows:

Fig. 1 schematically a process scheme in accordance with the present invention.

[0030] For the purpose of this description, a single reference number will be assigned to a line as well as a stream carried in that line. Same reference numbers refer to similar components.

[0031] Figure 1 schematically shows a process scheme and system (generally indicated with reference no. 100) used during the starting up of a liquefaction plant

1 for the liquefaction of a hydrocarbon feed stream 10 such as natural gas. The feed stream 10 may have been previously treated e.g. to remove propane and heavier hydrocarbons and/or other undesired components (such as H_2O, N_2, CO_2 and H_2S) to a certain extent before the actual liquefaction takes place.

[0032] The system 100 comprises a liquefaction plant 1 for the liquefaction of a natural gas feed stream 10, a storage tank 5 for storing the liquefied natural gas (LNG) as produced during normal operation (i.e. after the plant 1 has been started up) and a separate source 4 (in casu a storage tank, e.g. at an LNG import terminal) of already existing LNG that has been previously produced in a separate plant (not shown). If desired, the previously produced LNG may even be temporarily stored in the storage tank 5 forming part of the plant 1 to be started up as a result of which the tanks 4 and 5 may be one and the same.

[0033] The liquefaction plant 1 comprises a first heat exchanger 2 in which the feed stream 10 is heat exchanged against an evaporating refrigerant being cycled in a first refrigerant cycle 6. The first refrigerant cycle comprises a compressor 8 for recompressing refrigerant stream 40 being evaporated in the first heat exchanger 2 and a cooler 9 such as an air or water cooler for cooling the compressed stream 50. After cooling in the cooler 9 the refrigerant is recycled as stream 60 to the first heat exchanger 2 in which it is again evaporated to remove heat from the feed stream 10.

[0034] As shown in Fig. 1 the first heat exchanger 2 has an inlet 21 for the feed stream 10 and an outlet 22 for cooled stream 20.

[0035] The cooled stream 20 is passed to the inlet 31 of a second heat exchanger 3 in which during normal operation the actual liquefaction will take place. To this end the cooled stream 20 is heat exchanged in second heat exchanger 3 against an evaporating refrigerant being cycled in a second refrigerant cycle 7. Similar to the first refrigerant cycle 6, the second refrigerant cycle 7 comprises a compressor 11 for recompressing refrigerant stream 70 being evaporated in the second heat exchanger 3 and a cooler 12 such as an air or water cooler for cooling the compressed stream 80. After cooling in the cooler 12 the refrigerant is recycled as stream 90 to the second heat exchanger 3 in which it is again evaporated to remove heat from the cooled stream 20.

[0036] During normal operation of the plant 1 a liquefied stream 30 is removed at the outlet 32 of the second heat exchanger 3 and passed to a storage tank 5. If desired, more than the two refrigerant cycles 6, 7 may be present.

[0037] In the embodiment of Figure 1, the compressor 8 of the first refrigerant cycle 6 is driven by a gas turbine 13 that is fired using LNG taken (as stream 110) from the separate source 4 (at outlet 41) after it has been vaporized in vaporizer 15. The vaporized stream is passed on as stream 120 to the gas turbine 13. Reference number 130 indicates that the gas turbine can be mechanically connected to the compressor 8.

[0038] The person skilled in the art will understand that stream 110 may - alternatively or in addition - be used for firing a gas turbine (not shown), e.g. for driving the compressor 11 in the second refrigerant cycle 7.

[0039] During starting up of the plant 1 according to the present invention, liquefied stream 110 will be taken from the separate source 4 to assist in the starting up of the plant 1.

[0040] As an example, at least a part of the liquefied hydrocarbon stream 110 may be vaporized in vaporizer 15 and subsequently used as a fuel gas in the plant 1. The fuel gas may be used e.g. to commission fuel gas systems, for power generation of any gas turbines in the plant, to commission electrical distribution systems, to fire heaters, etc.

[0041] As shown in the embodiment of Figure 1, the fuel gas is passed on as stream 120 and used for firing the gas turbine 13 for driving the compressor 8 forming part of the refrigerant cycle 6 used for cooling at least a part of the hydrocarbon feed stream 10.

[0042] If desired, at least a part of the liquefied hydrocarbon stream 110 may also be used for providing electric power to the plant 1.

[0043] Furthermore at least a part of the liquefied hydrocarbon stream 110 may be vaporized in the vaporizer 15 and subsequently used as a commissioning gas in the plant 1, e.g. in a hydrocarbon purge process train, to dry out a mercury removal bed, to regenerate molecular sieves, to test refrigerant compressors, etc.

[0044] Further, at least a part of the liquefied hydrocarbon stream 110 may be introduced into the plant 1, in particular for cooling down the plant 1. To this end the liquefied hydrocarbon stream 110 may be introduced in e.g. the piping system and equipment of the plant. As an example, the liquefied hydrocarbon stream 110 may be used to cool down the loading system, piping systems (such as lines 10, 20 and 30), tanks (such as tank 5) and associated equipment and an end-flash system.

[0045] After the plant 1 has been started up, normal operation will take place and the separate source 4 may be disconnected from the plant 1, as the plant will then be in a position to generate its own fuel gas, if necessary.

[0046] The person skilled in the art will readily understand that many modifications may be made without departing from the scope of the invention. As an example, the compressors may comprise two or more compression stages. Further, each heat exchanger may comprise a train of heat exchangers.

Claims

1. Method for starting up a plant (1), preferably a new plant, for the liquefaction of a hydrocarbon feed stream (10) such as natural gas, wherein a liquefied hydrocarbon stream (110) that has been liquefied in a different liquefaction plant is used.

2. Method according to claim 1, wherein at least a part of the liquefied hydrocarbon stream (110) that has been liquefied in a different liquefaction plant is vaporized and subsequently used as a fuel gas in the plant (1).

3. Method according to claim 2, wherein the fuel gas is used for firing a gas turbine (13) of the plant (1), in particular for driving a compressor, preferably a compressor (8) forming part of a refrigerant cycle (6) used for cooling at least a part of the hydrocarbon feed stream (10).

4. Method according to claim 2 or 3, wherein the fuel gas is used for providing electric power to the plant (1).

5. Method according to one or more of the preceding claims, wherein at least a part of the liquefied hydrocarbon stream (110) that has been liquefied in a different liquefaction plant is vaporized and subsequently used as a commissioning gas in the plant (1).

6. Method according to one or more of the preceding claims, wherein at least a part of the liquefied hydrocarbon stream (110) that has been liquefied in a different liquefaction plant is introduced into the plant (1), in particular for cooling down the plant (1).

7. Method according to one or more of the preceding claims, wherein at least a part of the liquefied hydrocarbon stream (110) that has been liquefied in a different liquefaction plant is heat exchanged against a stream used in the plant (1).

8. Method according to one or more of the preceding claims, wherein the liquefied hydrocarbon stream (110) that has been liquefied in a different liquefaction plant is obtained from an offloading LNG carrier vessel.

9. System (100) for starting up a plant (1) for the liquefaction of a hydrocarbon feed stream (10) such as natural gas, the system (100) at least comprising:

- a plant (1) for the liquefaction of a hydrocarbon feed stream (10), the plant (1) at least comprising a heat exchanger (2) having an inlet (21) for the feed stream (10) to be cooled and an outlet (22) for a cooled stream (20), wherein the feed stream (10) can be heat exchanged against a refrigerant being cycled in a refrigerant cycle (6) containing at least a compressor (8) for compressing evaporated refrigerant (40);
- a storage tank (5) for storing a liquefied hydrocarbon stream (30) produced in the plant (1); and
- a source (4) of a liquefied hydrocarbon stream that has been liquefied in a different liquefaction plant.

10. System (100) according to claim 9, further comprising:

- a vaporizer (15) connected to an outlet (41) of the source (4) for vaporizing at least a part of the liquefied hydrocarbon stream from the source (4).

11. System (100) according to claim 10, further comprising:

- a gas turbine (13) connected to an outlet of the vaporizer (15).

12. System (100) according to claim 11, wherein the gas turbine (13) can drive a compressor (8) for compressing the evaporated refrigerant (40).

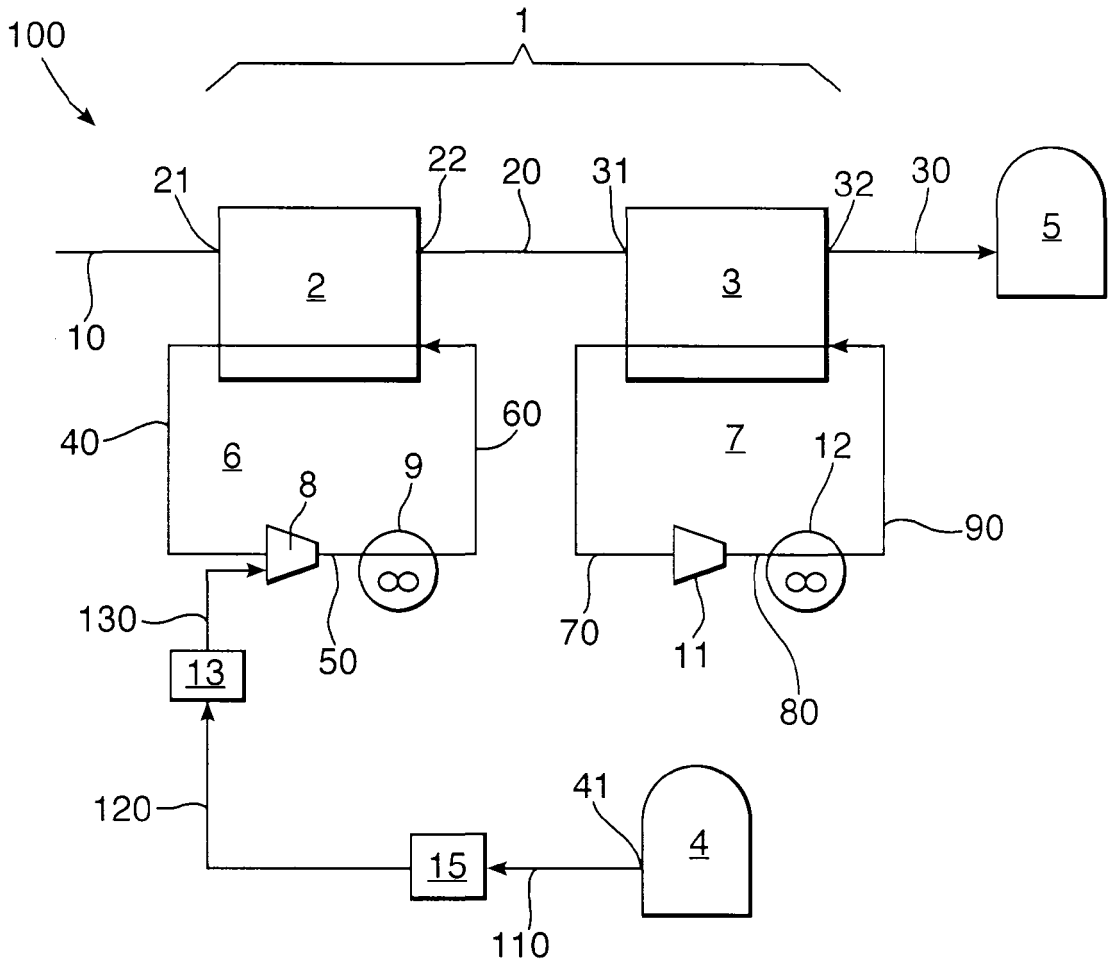
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Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 06 11 9677

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TECHNICAL FIELDS SEARCHED (IPC)

F25J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 March 2007	Göritz, Dirk

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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REFERENCES CITED IN THE DESCRIPTION

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