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(54) **PROCESS AND APPARTUS FOR REMOVING GASEOUS CONTAMINANTS FROM GAS STREAM COMPRISING GASEOUS CONTAMINANTS**

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(57) **ABSTRACT**

An apparatus and process for removing gaseous contaminants from a feed gas comprising methane and gaseous contaminants, in which the feed gas is cooled to obtain a slurry comprising solid contaminant, liquid contaminant and a methane enriched gaseous phase. The slurry is introduced into a separation device from which the methane enriched gaseous phase is removed. The slurry is diluted with liquid contaminant and passed through a heat exchanger wherein solid contaminant is melted into liquid contaminant. A stream comprising liquid contaminant is removed from the separation device at a position below the slurry level in the separation device by means of a pump and at least part of the removed liquid contaminant is recovered as a stream product and at least part is recycled and introduced into the separation device to dilute the slurry inside the separation device.

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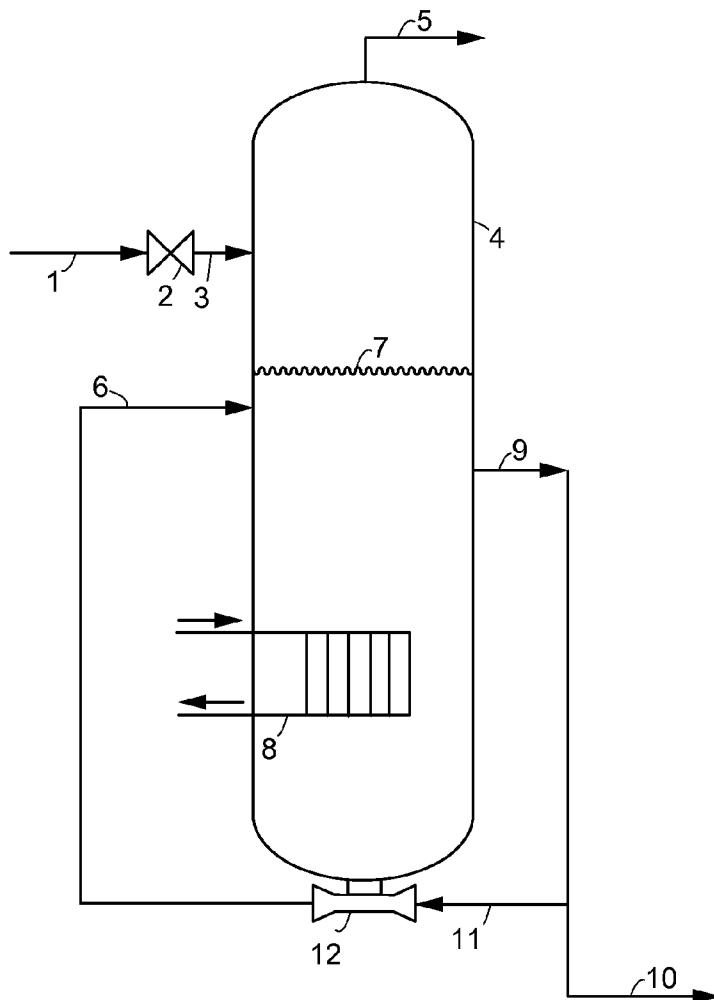
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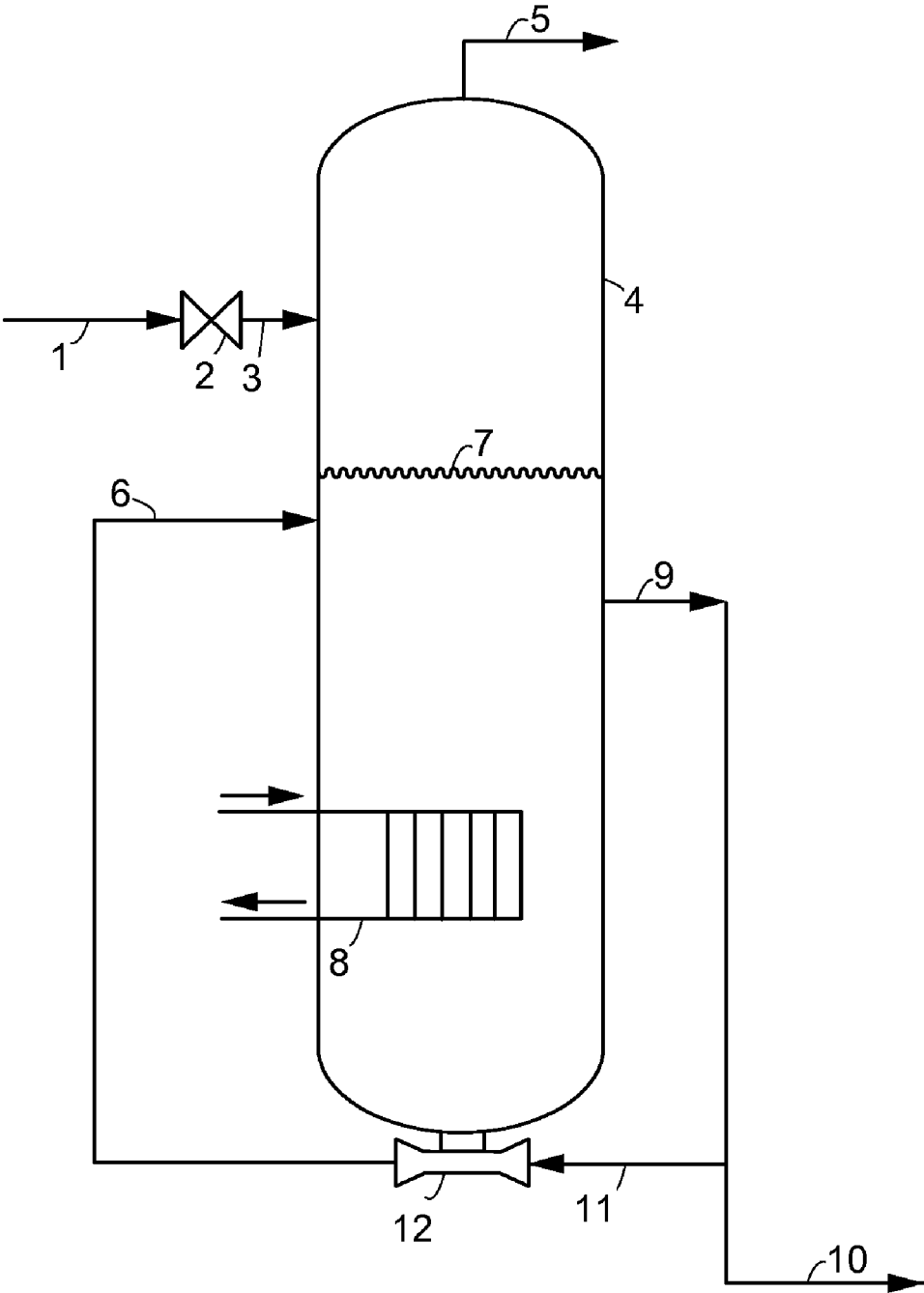


FIGURE 1

**PROCESS AND APPARATUS FOR REMOVING
GASEOUS CONTAMINANTS FROM GAS
STREAM COMPRISING GASEOUS
CONTAMINANTS**

[0001] The present invention concerns a process for removing gaseous contaminants, especially carbon dioxide and/or hydrogen sulphide, from a feed gas stream comprising methane and gaseous contaminants. The invention further comprises a cryogenic separation device to carry out the process, as well as products made in the process.

[0002] The removal of acid contaminants, especially carbon dioxide and/or hydrogen sulphide, from methane containing gas streams has been described in a number of publications.

[0003] In WO 03/062725 a process is described for the removal of freezable species from a natural gas stream by cooling a natural gas stream to form a slurry of solid acidic contaminants in compressed liquefied natural gas. The solids are separated from the liquid by means of a cyclone. It will be clear that a complete separation of the liquid from the solids is not easily achieved.

[0004] In U.S. Pat. No. 4,533,372 a cryogenic process is described for the removal of carbon dioxide and other acidic gases from methane-containing gas by treating the feed stream in a distillation zone and a controlled freezing zone. This is a rather complicated process requiring very specific equipment.

[0005] In U.S. Pat. No. 3,398,544 the removal of acid contaminants from a natural gas stream is described by cooling to liquefy the stream and to partly solidify the stream, followed by expansion and separation of cleaned gas and liquid streams from the solids. Solid contaminants need to be removed from the separation vessel, which is a complicated process when the loss of natural gas liquid is to be minimized.

[0006] In WO 2004/070297 a process for removing contaminants from a natural gas stream has been described. In a first step, water is removed from the feed gas stream. This is especially done by cooling the feed gas stream resulting in methane hydrate formation, followed by removal of the hydrates. Further cooling results in the formation of solid acidic contaminants. After separation of the solid acidic contaminants a cleaned natural gas stream is obtained. It is preferred to convert the solid contaminant into a liquid by heating the solids.

[0007] A problem of the process as described in WO 2004/070297 is the removal of the contaminants in a reliable way from the separation vessel, as well as the removal of a pure liquid only, free from solid particles. In this respect it is observed that the continuous stream of solid particles in the described process will occasionally result in the formation of a thick layer of solid material on top of the heat exchanger. Furthermore, a layer of solid material may built up on the bottom of the vessel since solid CO₂ has a high density compared to the liquid stream. In addition, this could result in uneven distribution of the heat input required for melting and could result in hot gas plumes forming from the liquid decreasing the clean natural gas stream quality. Also, it is important to withdraw a pure liquid stream from the vessel, in order to avoid blockages in the piping system and/or heat exchangers, as well as damages of pumps and other devices.

[0008] Object of the present invention is to provide an improved cryogenic separation process which attractively deals with the above-indicated problems.

[0009] Surprisingly it is now been found that this can be established by means of a particular sequence of process steps wherein use is made of a pump, especially an eductor device, a heat exchanger arranged outside the separation device and the recirculation of liquid phase contaminant obtained from the heat exchanger.

[0010] Accordingly, the present invention relates to a process for removing gaseous contaminants from a feed gas stream which comprises methane and gaseous contaminants, the process comprising:

- 1) providing the feed gas stream;
- 2) cooling the feed gas stream to a temperature at which a slurry is formed which comprises solid contaminant, liquid phase contaminant and a methane enriched gaseous phase;
- 3) introducing the slurry as obtained in step 2) into the top part or intermediate part of a cryogenic separation device;
- 4) removing from the top part of the separation device a stream which comprises the methane enriched gaseous phase;
- 5) introducing a stream comprising liquid phase contaminant into the intermediate part or the bottom part of the separation device or both; to dilute the slurry which has been introduced into the separation device in step 3);
- 6) passing the diluted slurry as obtained in step 5) through a heat exchanger which is arranged inside the separation device, whereby at least part of the solid contaminant present in the diluted slurry is melted into liquid phase contaminant;
- 7) removing from the separation device by means of a pump, preferably an eductor, a stream comprising liquid phase contaminant, which pump is situated below the heat exchanger and arranged outside or inside the separation device or partly inside or outside the separation device;
- 8) removing a stream comprising liquid phase contaminant from the separation device at a position below the slurry level in the separation device;
- 9) separating the stream of liquid phase contaminant obtained in step 8) into a liquid product stream and a recirculation stream which is used as a motive fluid in the eductor in the case that an eductor is used; and
- 10) introducing into the separation device as described above in step 5) at least part of the stream as removed in step 7) and at least part of the recirculation stream as obtained in step 9).

[0011] The present invention uses a recirculation loop of a liquid or slurry stream over the separation device. To achieve the circulation stream, a liquid or slurry stream is withdrawn downstream of the internal heat exchanger by means of a pump, preferably an eductor, and at least part of the obtained stream is recirculated to the zone above the heat exchanger. Thus, a continuously moving slurry phase is obtained, minimizing any blockages in the separation vessel. Further, a fully liquid stream is withdrawn, especially from the slurry zone above the heat exchanger. Thus, the risk of blockages in pipelines or heat exchangers after the separation device is minimal, and no damages will occur to any devices having moving parts, as pumps.

[0012] It is further observed that when pure liquid stream is withdrawn from the space above the heat exchanger, a relatively cold liquid stream is obtained, thus maintaining a high amount of exchangeable cold in the product stream. The absence of solid particles in the product stream also minimizes any forms of erosion in the pipelines and other pieces of equipment.

[0013] It is observed that the liquid phase contaminant as described in step 7) above, as well as the liquid phase contaminant as described in step 9) above, may contain some vapor and/or flash gas, e.g. up till 10 wt %, especially up till 5 wt %, more especially up till 2 wt %, of the total liquid phase contaminant.

[0014] Suitably, the feed gas stream to be used in accordance with the present invention is a natural gas stream in which the gaseous contaminants are carbon dioxide and/or hydrogen sulphide and/or C₂+hydrocarbons.

[0015] The amount of the hydrocarbon fraction in the feed gas stream is suitably from 10 to 85 mol % of the gas stream, preferably from 25 to 80 mol %. The hydrocarbon fraction of the natural gas stream comprises especially at least 75 mol % of methane, preferably 90 mol %. The hydrocarbon fraction in the natural gas stream may suitably contain from 0 to 20 mol %, suitably from 0.1 to 10 mol %, of C₂-C₆ compounds. The gas stream may also comprise up to 20 mol %, suitably from 0.1 to 10 mol % of nitrogen, based on the total gas stream.

[0016] The amount of carbon dioxide in the gas stream is suitably from 10 to 90 vol %, preferably from 20 to 75 vol %, and/or the amount of hydrogen sulphide in the gas stream is suitably from 5 to 40 vol % of the gas stream, preferably from 20 to 35 vol %. Basis for these amounts is the total volume of hydrocarbons, hydrogen sulphide and carbon dioxide. It is observed that the present process is especially suitable for gas streams comprising large amounts of sour contaminants, e.g. 10 vol % or more, suitably from 15 to 90 vol %, and is especially suitable for gas streams comprising carbon dioxide as contaminant.

[0017] In the process according to the present invention the feed gas stream in step 1) has suitably a temperature between -20 and 150° C., preferably between -10 and 70° C., and a pressure between 10 and 250 bara, preferably between 80 and 120 bara.

[0018] The feed gas stream may be pre-treated for partial or complete removal of water and optionally some heavy hydrocarbons. This can for instance be done by means of a pre-cooling cycle, against an external cooling loop, a cold internal process stream, or a cold LNG stream. Water may also be removed by means of pre-treatment with molecular sieves, e.g. zeolites, aluminium oxide or silica gel or other drying agents. Water may also be removed by means washing with glycol, MEG, DEG or TEG, or glycerol. Other processes for forming methane hydrates or for drying natural gas are also possible. The amount of water in the gas feed stream is suitably less than 1 vol %, preferably less than 0.1 vol %, more preferably less than 0.01 vol %. Water may also be removed by hydrate formation in the way as described in WO2004/070297. Suitably, water is removed until the amount of water in the natural gas stream comprises at most 50 ppmw, preferably at most 20 ppmw, more preferably at most 1 ppmw of water, based on the total feed gas stream.

[0019] The cooling in step 2) of the present process can suitably be done by isenthalpic expansion, preferably isenthalpic expansion over an orifice or a valve, especially a Joule-Thomson valve, or in which the cooling is done by nearly isentropic expansion, especially by means of an expander, preferably a turbo expander or a laval nozzle. A valve is in particular preferred.

[0020] In step 2) the feed gas stream is suitably cooled to a temperature between -40 and -100° C., preferably between -50 and -80° C.

[0021] Suitably, the feed gas stream is pre-cooled to a temperature between 15 and -45° C., preferably between 5 and -25° C., before expansion.

[0022] Suitably, such a pre-cooling of the feed gas stream is done by heat exchange against a cold fluidum, especially an external refrigerant, e.g. a propane cycle, an ethane/propane cascade or a mixed refrigerant cycle, or an internal process loop, suitably a carbon dioxide or hydrogen sulphide stream, or a cold methane stream.

[0023] Preferably, the present process is carried out in such a way that substantially all the solid contaminant present in the diluted slurry of contaminants is melted into liquid phase contaminant in step 6). With the phrase "substantially" is meant that at least 95% of the solid contaminant present in the diluted slurry is melted, especially at least 98%. More preferably, all the solid contaminant present in the diluted slurry of contaminants is melted in step 6).

[0024] Suitably, between 0 and 90 vol % of the liquid phase contaminant which is removed from the separation device in step 7) is introduced in the separation device as described in step 5), preferably between 5 and 80 vol % of the liquid phase contaminant as removed in step 7). It is also possible to introduce all liquid phase contaminant removed in step 7) in the separation device as described in step 5).

[0025] In step 8) the stream comprising liquid phase contaminant is suitably removed from the separation device at a position above the heat exchanger.

[0026] In the present invention solid contaminant will mainly comprise carbon dioxide, whereas liquid phase contaminant will usually comprise both carbon dioxide and hydrogen sulphide. A small amount of hydrocarbons may be present.

[0027] Preferably, the pump is arranged outside the separation device and the pump communicates with the separation device. Preferably, the pump is an eductor.

[0028] Eductors, also referred to as siphons, exhausters, ejectors or jet pumps, are as such well-known and have extensively been described in the prior art. Reference herein to an eductor is to a device to pump produced solid and liquid CO₂ slurry from the separator to the heat exchanger. The eductor is suitably designed for use in operations in which the head pumped against is low and is less than the head of the fluid used for pumping. For a description of suitable eductors, also referred to as eductors or jet pumps, reference is made to Perry's Handbook for Chemical Engineering, 8th edition, chapter 10.2. In accordance with the present invention any type of eductor can be used. The eductor is preferably a liquid jet solid pump.

[0029] Preferably, the eductor is arranged inside the separation device or partly inside and outside the separation device.

[0030] Suitably, a housing can be positioned around the eductor, enabling the eductor to be removed from the separation device. Such a housing can, for instance, be a vessel like containment, e.g. a pipe, that can be isolated from the process through valves.

[0031] In another embodiment of the present invention the eductor is arranged outside the separation device. Such an embodiment can be useful in situations in which the eductor in use needs to be repaired or replaced.

[0032] The eductor can be of such a size that it fits completely in the separation device or it may cover the entire

diameter of the separation device, usually a vessel. However, it may also extend at two locations through the internal wall of the separation device.

[0033] More preferably, the eductor is arranged below the central bottom part of the separation device.

[0034] Suitably, in step 10) between 25 and 95 vol % of the stream of liquid phase contaminant removed from the separation device in step 9) is used as a motive fluid in the eductor, preferably between 30 and 85 vol % of the stream of liquid phase contaminant removed from the separation device in step 9).

[0035] In general, the methane enriched gaseous phase is removed from the top part of the cryogenic separation device at a high level, preferably at the top of the reactor.

[0036] The outlet for the methane enriched gaseous phase will usually be above the level at which the stream of liquid phase contaminant obtained from the heat exchanger is introduced into the separation device in step 5).

[0037] The cooling process as described in step (2) of the present process is preferably carried out at a close distance, e.g. up to a few meters, preferably at most 1 m, to the separator vessel. It may also be done inside the separation vessel, thus minimizing any problems due to the transport of the solid particles. The separation device is suitably a vessel which comprises a vertical cylindrical housing. The diameter may vary from 1 to 10 meter, or even more, the height may vary from 3 to 35 meters or even more. In general, the slurry level in the separation vessel will vary between 30 and 70% of the height of the vessel. The temperature of the slurry is suitably about 1 to 45° C. higher than the temperature of the contaminated gas stream on introduction is the separator vessel, preferably 3 to 40° C.

[0038] The heat exchanger preferably uses a process stream to supply the heat for melting the solid contaminants. A suitable process stream is the methane enriched gaseous phase.

[0039] A suitable internal structure to remove the stream comprising liquid phase contaminant from the separation device in step 9) is a conical section or a cylindrical section that is closed at the upper end. Also a standpipe may be used with a closed upper end to prevent solids transport with this liquid stream. In addition, filters may be used, suitably equipped with heat tracing to prevent blockage.

[0040] The content of contaminants in the methane enriched gaseous phase as removed from the separation device in step 4) is suitably less than 10 vol %, preferably less than 5 vol %. The content of methane in the contaminants product stream is suitably less than 2 wt %, preferably less than 1 wt %, based on total weight of the stream.

[0041] The feed gas stream provided in step 1) of the present process can suitably have been subjected to one or more purification processes in which gaseous contaminants are removed from a feed gas stream, before step 2) of the present process is carried out.

[0042] Such a purification process can suitably comprise the steps of:

- a) providing a feed gas stream;
- b) cooling the feed gas stream to a temperature at which liquid phase contaminant is formed as well as a methane enriched gaseous phase; and
- c) separating the two phases obtained in step 2) by means of a gas/liquid separator.

[0043] Suitably, steps a) and b) can be repeated twice or three times before step 2) in accordance with the present

invention is carried out. Such a process has, for instance been described in WO 2006/087332 which is hereby incorporated by reference. Hence, the feed gas stream can be subjected to a number of combinations of subsequent cooling and separation steps, before step 2) of the present invention is carried out.

[0044] Suitably, after step a) the methane enriched gaseous phase can be recompressed in one or more compression steps before step 2) in accordance with the present invention is carried out.

[0045] In another embodiment of the invention the feed gas stream may between steps 1) and 2) be cooled to a temperature at which at least part of the feed gas stream is present in the liquid phase, the cooled feed stream so obtained may be separated by means of a cryogenic distillation into a bottom stream rich in liquid phase contaminant and lean in methane and into a top stream rich in methane and lean in gaseous contaminant, and the feed gas stream so obtained may then be subjected to the remaining steps 2)-10) of the process according to the present invention.

[0046] The cryogenic distillation section to be used in the cryogenic distillation is as such known in the art.

[0047] Suitably, the feed gas stream is cooled to a temperature between -10 and -50° C., preferably between -20 and -40° C. before introduction into the cryogenic distillation section.

[0048] Suitably, the bottom temperature of the cryogenic distillation section is between -15 and 35° C., preferably between -5 and 30° C. A reboiler may be present to supply heat to the column.

[0049] Suitably, the top temperature of the cryogenic distillation section is between -70 and -40° C., preferably between -60 and -30° C. In the top of the cryogenic distillation column a condenser may be present, to introduce cold into the column.

[0050] In order to reach gas line specifications or LNG specifications for the methane stream, the methane enriched gaseous phase obtained in step 4) may further be purified, in an additional cryogenic distillation process using a cryogenic distillation section which is as such known in the art.

[0051] Suitably, in such an additional cryogenic distillation process the bottom temperature of the cryogenic distillation section is between -30 and 10° C., preferably between -10 and 5° C. A reboiler may be present to supply heat to the distillation section.

[0052] Suitably, the top temperature of the cryogenic distillation section is between -110 and -80° C., preferably between -100 and -90° C. In the top of the cryogenic distillation section a condenser may be present, to provide reflux and a liquefied (LNG) product.

[0053] As an alternative, further purification of the methane enriched gaseous phase may be accomplished by absorption with a suitable absorption liquid. Suitable absorbing liquids may comprise chemical solvents or physical solvents or mixtures thereof.

[0054] A preferred absorbing liquid comprises a chemical solvent and/or a physical solvent, suitably as an aqueous solution.

[0055] Suitable chemical solvents are primary, secondary and/or tertiary amines, including sterically hindered amines.

[0056] A preferred chemical solvent comprises a secondary or tertiary amine, preferably an amine compound derived from ethanolamine, more especially DIPA, DEA, MMEA (monomethyl-ethanolamine), MDEA (methyldiethanola-

mine) TEA (triethanolamine), or DEMA (diethyl-monoethanolamine), preferably DIPA or MDEA. It is believed that these chemical solvents react with acidic compounds such as CO₂ and H₂S.

[0057] Suitable physical solvents include tetramethylene sulphone (sulpholane) and derivatives, amides of aliphatic carboxylic acids, N-alkyl pyrrolidone, in particular N-methyl pyrrolidone, N-alkyl piperidones, in particular N-methyl piperidone, methanol, ethanol, ethylene glycol, polyethylene glycols, mono- or di(C1-C4)alkyl ethers of ethylene glycol or polyethylene glycols, suitably having a molecular weight from 50 to 800, and mixtures thereof. The preferred physical solvent is sulfolane. It is believed that CO₂ and/or H₂S are taken up in the physical solvent and thereby removed.

[0058] Other treatments of the methane enriched gaseous phase may include a further compression, when the purified gas is wanted at a higher pressure. If the amounts of acidic contaminants in the purified gas are undesirably high, the purified gas may be subjected to one or more repetitions of the present process.

[0059] It is an advantage of the present process enables purification of natural gas comprising substantial amounts of acidic contaminants, resulting in purified natural gas comprising low levels of contaminants, especially of sulphur contaminants. The production of LNG from such natural gas, which would be very difficult if not impossible by conventional processes, is made possible. Thus, the invention also provides LNG obtained from liquefying purified natural gas obtained by the process. The LNG thus-obtained typically has very low concentrations of contaminants other than natural gas.

[0060] In general, the top part of the separation device will comprise the top quarter length of the device. The bottom part will comprise the lower quarter up till the lower half of the length of the device. The intermediate part will comprise the remaining.

[0061] The present invention also relates to a cryogenic separation device for carrying out the process according to the present process, which separation device comprises a top part, an intermediate part and a bottom part; means to introduce a slurry which comprises solid contaminant, liquid phase contaminant and a methane enriched gaseous phase into the top or intermediate part of the separation device; means to remove a methane enriched gaseous phase from the top part of the separation device; means for introducing a stream comprising liquid phase contaminant into the top or intermediate part of the separation device to dilute the slurry inside the separation device; a heat exchanger arranged inside the separation device; a pump, preferably an eductor, which is arranged inside or outside the separation device or partly inside and outside the separation device at a level which is below the level at which the heat exchanger is arranged for removing a stream comprising liquid phase contaminant from the separation device; means to remove a stream comprising liquid phase contaminant from the intermediate or bottom part of the separation device; and means to separate liquid phase contaminant removed from the intermediate or bottom part into a liquid product stream and a recirculation stream for use as a motive fluid in the eductor in the case an eductor is used.

[0062] Preferably, the slurry pump, preferably an eductor, is arranged outside and communicates with the separation device. Preferably, the pump, preferably an eductor is

arranged below the separation device. More preferably, it is arranged below the central bottom part of the separation device.

[0063] The process is also suitable for the removal in general of carbon dioxide from carbon dioxide comprising streams, especially (partial)oxidation flue gas streams, more especially streams comprising (beside carbon dioxides) hydrogen, carbon monoxide, nitrogen and/or oxygen, for instance boiler flue gas streams (usually comprising mainly carbon dioxide, nitrogen and oxygen), partial oxidation process streams (usually containing mainly carbon dioxide, carbon monoxide, hydrogen and optionally nitrogen), steam methane reforming process streams (usually comprising hydrogen, carbon dioxide and carbon monoxide).

[0064] In the event that the contaminant-rich stream mainly comprises carbon dioxide and is therefore a CO₂-rich stream, preferably CO₂-rich stream is further pressurised and injected into a subterranean formation, preferably for use in enhanced oil recovery or for storage into an aquifer reservoir or for storage into an empty oil reservoir. It is an advantage that a liquid CO₂-rich stream is obtained, as this liquid stream requires less compression equipment to be injected into a subterranean formation. Preferably, at least 90%, more preferably at least 95% and most preferably at least 98% of the solid acidic contaminants are melted. In this way a liquid stream of contaminants is obtained, which can be easily transported further.

[0065] The present invention further relates to a purified gas stream obtained by a process according to the present invention.

[0066] The present invention also relates to a process for liquefying a feed gas stream comprising purifying the feed gas stream in accordance with the present invention, followed by liquefying the feed gas stream by methods known in the art.

[0067] The invention will be further illustrated by means of FIG. 1. In FIG. 1, a natural gas is passed via a conduit 1 through an expansion means 2, especially a Joule Thomson valve, whereby a stream is obtained of a slurry which comprises solid contaminant, liquid phase contaminant and a methane enriched gaseous phase. The stream of the slurry flows via a conduit 3 into cryogenic separation vessel 4. A methane enriched gaseous phase is removed from the separation vessel via a conduit 5. A stream of liquid phase contaminant is introduced into the separation device via a conduit 6 to dilute the slurry inside the separation device, establishing or maintaining a slurry level 7. The diluted slurry passes then towards a heat exchanger 8. Via a conduit 9 a stream comprising liquid phase contaminant is removed from the separation device, whereby part of the stream is recovered as a liquid product via a conduit 10. Another part of the stream is passed via a conduit 11 to an eductor 12 where it is used as motive fluid, after which it is recirculated to the separation device via the conduit 6.

1. A for removing gaseous contaminants from a feed gas stream which comprises methane and gaseous contaminants, the process comprising:

- 1) providing the feed gas stream;
- 2) cooling the feed gas stream to a temperature at which a slurry is formed which comprises solid contaminant, liquid phase contaminant and a methane enriched gaseous phase;

- 3) introducing the slurry as obtained in step 2) into the top part or intermediate part of a cryogenic separation device;
 - 4) removing from the top part of the separation device a stream which comprises the methane enriched gaseous phase;
 - 5) introducing a stream comprising liquid phase contaminant into the intermediate part or the bottom part of the separation device or both to dilute the slurry which has been introduced into the separation device in step 3);
 - 6) passing the diluted slurry as obtained in step 5) through a heat exchanger which is arranged inside the separation device, whereby at least part of the solid contaminant present in the diluted slurry is melted into liquid phase contaminant;
 - 7) removing from the separation device by means of a pump, preferably an eductor, a stream comprising liquid phase contaminant, which pump is situated below the heat exchanger and arranged outside or inside the separation device or partly inside or outside the separation device;
 - 8) removing a stream comprising liquid phase contaminant from the separation device at a position below the slurry level in the separation device;
 - 9) separating the stream of liquid phase contaminant obtained in step 8) into a liquid product stream and a recirculation stream which is used as a motive fluid in the eductor in the case that an eductor is used; and
 - 10) introducing into the separation device as described above in step 5) at least part of the stream as removed in step 7) and at least part of the recirculation stream as obtained in step 9).
2. A process according to claim 1, in which the pump, is arranged outside the separation device and communicates with the separation device.
3. A process according to claim 1 in which the feed gas stream is a natural gas stream in which the gaseous contaminants are carbon dioxide and/or hydrogen sulphide and/or C₂₊ hydrocarbons.
4. A process according to claim 3, in which the natural gas stream comprises between 5 and 50 vol % of hydrogen sulphide.
5. A process according to claim 3 or 4, in which the natural gas stream comprises between 5 and 90 vol % of carbon dioxide.
6. A process according to claim 1 in which the feed gas contains between 0 and 25 vol % of C₂₊ hydrocarbons.
7. A process according to claim 1 in which the feed gas stream comprises between 75 and 100 vol % of methane.

8. A process according to claim 1 in which the feed gas stream in step 1) has a temperature between -20 and 150° C., preferably between -10 and 70° C., and a pressure between 10 and 250 bara, preferably between 80 and 120 bara.

9. A process according to claim 1 in which the cooling in step 2) is done by isenthalpic expansion.

10. A process according to claim 1 in which the feed gas stream is cooled in step 2) to a temperature between -40 and -100° C.

11. A process according to claim 1 in which substantially all the solid contaminant present in the slurry of contaminants is melted in step 6).

12. A process according to claim 1 in which in step 5) the stream comprising liquid phase contaminant or the slurry contaminants stream is introduced into the separation device at a level which is lower than the level at which the methane enriched gaseous phase is removed from the separation device in step 4).

13. A cryogenic separation device for carrying out the process according to claim 1, which separation device comprises a top part, an intermediate part and a bottom part; means to introduce a slurry which comprises solid contaminant, liquid phase contaminant and a methane enriched gaseous phase into the top or intermediate part of the separation device; means to remove a methane enriched gaseous phase from the top part of the separation device; means for introducing a stream comprising liquid phase contaminant into the top or intermediate part of the separation device to dilute the slurry inside the separation device; a heat exchanger arranged inside the separation device; a pump, which is arranged at a level which is below the level at which the heat exchanger is arranged for removing a stream comprising liquid phase contaminant from the separation device; means to remove a stream comprising liquid phase contaminant from the intermediate or bottom part of the separation device; and means to separate liquid phase contaminant removed from the intermediate or bottom part into a liquid product stream and a recirculation stream for use as a motive fluid in the eductor in the case an eductor is used, in which the pump is arranged outside the separation device and communicates with the separation device.

14. A Purified gas stream obtained by a process according to claim 1.

15. A process for liquefying a feed gas stream comprising purifying the feed gas stream according to claim 1, followed by liquefying the feed gas stream by methods known in the art.

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