(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 447 653 A1**

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
02.05.2012 Bulletin 2012/18

(51) Int Cl.:
***F25J 3/04** (2006.01)*

(21) Application number: **10014198.5**

(22) Date of filing: **02.11.2010**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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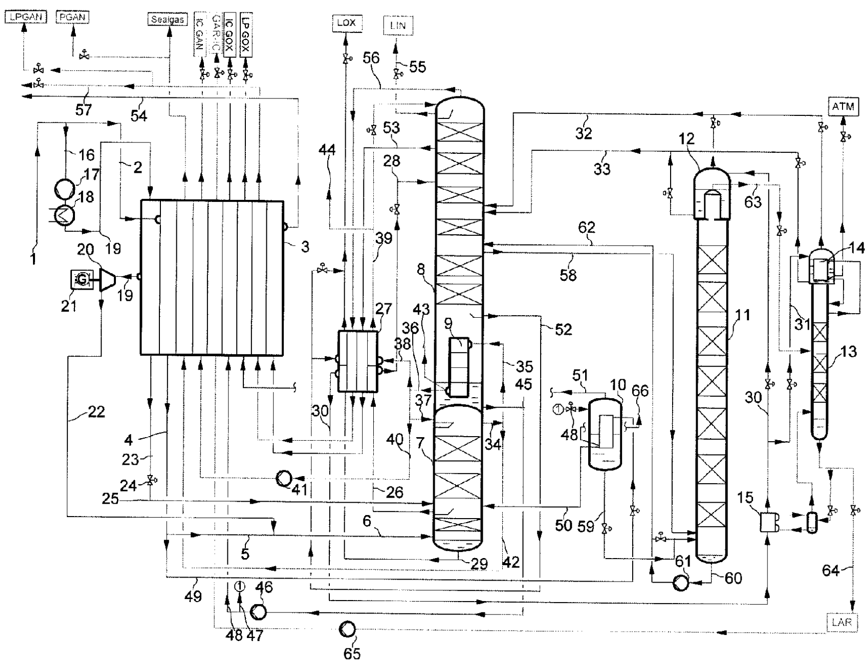
(54) Process for cryogenic air separation using a side condenser

(57) The invention relates to a process for cryogenic air separation in a distillation system comprising a high pressure column (7), a low pressure column (8), a side condenser (10) having an evaporation space and a crude argon distillation system comprising at least a first crude argon column (12). Feed air is compressed and purified. At least a portion of the purified feed air (1) is cooled in a main heat exchanger. At least a portion of the cooled feed is fed to the high pressure column (7). A first liquid oxygen stream (48) withdrawn from the low pressure column (8) is at least partially evaporated in the evaporation space of the side condenser (10) by indirect heat exchange with a heating medium (49). A first gaseous oxygen stream (51) produced by the evaporation of the first liquid oxygen stream is withdrawn from the evaporation space of the side condenser (10), warmed in the main heat exchanger (3) and finally withdrawn as a first gaseous oxygen product stream (LP-GOX). A liquid purge stream (59) is withdrawn from the side condenser. The liquid purge stream (59) is introduced into the crude argon distillation system.



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Description

[0001] The invention relates to a process for cryogenic air separation according to the first part of patent claim 1.

[0002] Two or more column air separation processes are well-known. Side condensers are frequently used to enable the withdrawal of a gaseous oxygen product of a pressure higher than the low pressure column pressure. In order to avoid enrichment of heavier components of the air, such side condensers must be purged.

[0003] A respective process is known from US 5098456 , where the purge liquid from the side condenser is cooled in a subcooler and withdrawn as a liquid product. Such processing constitutes a waste of energy, if no liquid oxygen product of respective purity is needed. Alternatively, a side condenser purge liquid could be reintroduced into the low pressure column as shown in DE 2323941 , requiring, however an additional pump for lifting the purge liquid.

[0004] The object of the invention is to find a particularly advantageous method for processing the purge liquid of a side condenser in an above-mentioned process, leading in particular to a relatively small energy consumption of the overall process.

[0005] Such an objective is achieved by introducing the liquid purge stream into the crude argon distillation system.

[0006] The crude argon system usually has a column bottom located lower that the low pressure column bottom which the first crude argon column is connected with. In order to transfer the argon-depleted liquid from such column bottom back to the low pressure column, a transfer pump is needed anyway. By introducing the purge liquid from the side condenser into the crude argon distillation system, the afore-mentioned transfer pump may be simultaneously used for recycling the purge liquid from the side condenser back into the rectification system. Since the purge flow is significantly smaller than the reflux flow rate in the crude argon distillation, it will not change the total flow of the transfer pump very much. The same applies for the concentration of the liquid return stream fed into the low pressure column. In the invention, the purge liquid is not lost from the system and there is no need for either additional apparatus, nor for additional energy for recycling the purge liquid.

[0007] The "crude argon distillation system" can be formed by a single crude argon column as shown in US 5098456, or by multiple serially connected crude argon columns, e.g. by a split crude argon column system with a first crude argon column and a second crude argon column as shown in EP 628777 B1.

[0008] According to further aspects of the invention

- the liquid purge stream is introduced into the bottom of the first crude argon column and/or
- a liquid return stream from the bottom of the first crude argon column is fed to the low pressure column via a transfer pump

[0009] The process of the invention is particularly useful if a second liquid oxygen stream is withdrawn from the low pressure column, the second liquid oxygen stream being pressurized to pressure considerably above the low pressure column pressure, (pseudo-) evaporated and warmed in the main heat exchanger and finally withdrawn as a second gaseous oxygen product stream having a higher pressure than the first gaseous oxygen product stream. Such well-known type of process is called "internal compression of oxygen". If the elevated pressure of the oxygen is above its critical pressure, it is pseudo-evaporated in the main heat exchanger, otherwise it is evaporated in the literal sense.

[0010] Further details of the invention are explained in the following description in relation to a specific embodiment of the invention schematically shown in the drawing.

[0011] Atmospheric air is compressed in an air compressor, pre-cooled and afterwards purified in a molecular sieve (not shown in the drawing). The purified feed air 1 is split into a first partial stream 2 and a second partial stream 16. The first partial stream 2 of the purified feed air enters a main heat exchanger 3 at an intermediate temperature close to its warm end. A first portion 5 of the cooled first partial stream 4 is fed via line 6 into the high pressure column 7 of a distillation system comprising as well a low pressure column 8, a main condenser 9, a side condenser 10, a crude argon column 11 with head condenser 12 (the crude argon column 11 constituting the "first" and single crude argon column in the embodiment) and a pure argon column 13 having a head condenser 14 and a bottom reboiler 15. A second portion 49 is fed to the condensation space of side condenser 10 and used as the heating medium. The condensed air 50 is introduced into the high pressure column 6. The remaining gaseous portion 66 may be fed into a helium-neon recovery system.

[0012] The second partial stream 16 is further compressor in a booster compressor 17 with aftercooler 18 and introduced into the main heat exchanger 3 at its warm end via line 19. A first portion 19 of the second partial stream is withdrawn from the main heat exchanger 19 at a further intermediate temperature and work-expanded in an expansion turbine 20, which is mechanically coupled to an electric generator 21. The work-expanded air 22 is fed into the high pressure column via line 6. The rest of the second partial stream continues its cooling in the main heat exchanger up to the cold end. The cold air 23 is expanded in an expansion valve 24 to high pressure column pressure and introduced, at least partially in liquid form, via line 25 into the high pressure column 7 at an intermediate height some practical or theoretical trays above the bottom where the gaseous air 6 enters the high pressure column 7. A portion 26 of the liquid air may be cooled in a subcooler 27 and directly introduced into the low pressure column 8 at an intermediate height via line 28.

[0013] Bottom liquid 29 from the high pressure column 6 is cooled in subcooler 27 and fed via line 15 through the pure argon bottom reboiler 15 and via lines 31 and 32 to the evaporation spaces of the head condensers 12 and 14. Vapor 32 produced in the head condensers and remaining liquid 33 are fed to the low pressure column 8.

[0014] A first portion 35 of the top nitrogen 34 from the high pressure column 6 is at least partially condensed in the main condenser 9 in indirect heat exchange with the bottom liquid of the low pressure column 6. Liquid nitrogen 36 produced in the main condenser 9 is split into three portions: A first portion 37 is fed as reflux liquid to the top of the high pressure column 6. A second portion 38, 39 is subcooled (27) and fed as reflux liquid to the top of the high pressure column 6. A third portion 40 may be internally compressed by pressurizing it in a pump 41, (pseudo-)evaporating and warming it in the main heat exchanger 3 and withdrawing it as an internally compressed high-pressure product (IC-GAN).

[0015] Another portion 42 of the top nitrogen 34 is directly taken as a pressurized product by leading it through the main heat exchanger 3 and finally withdrawing it as pressurized product (PGAN) or using it as seal gas (Sealgas).

[0016] Uncondensed gases 43 from the main condenser 9 may be fed to a helium-neon recovery system. Refrigeration for such system may be delivered by a portion 44 of the subcooled liquid nitrogen.

[0017] Liquid oxygen 45 from the bottom of the low pressure column 8 is pressurized in an oxygen pump 46 to an elevated pressure, considerably above the low pressure column pressure. The pressurized oxygen is divided into a first liquid oxygen stream 47 and a second liquid oxygen stream 48. The first liquid oxygen stream 47 is expanded in expansion valve 48 to an intermediate pressure still above the low pressure column pressure and fed to the evaporation space of the side condenser 10. The first gaseous oxygen stream 51 produced in the evaporation space of side condenser 10 is warmed in the main heat exchanger 3 and finally withdrawn as a first gaseous oxygen product stream (LP-GOX). According to the invention, a liquid purge stream 59 from the evaporation space of the side condenser 10 is introduced into the argon distillation system, in this embodiment it is illustrated as going into the bottom of the crude argon column 12.

[0018] The second liquid oxygen stream 48 is (pseudo-)evaporated and warmed in the main heat exchanger 3 and finally withdrawn as a second, internally compressed gaseous oxygen product stream (IC-GOX).

[0019] A third liquid oxygen stream 52 is withdrawn immediately above the bottom of the low pressure column 8, partially subcooled (27 and withdrawn as liquid oxygen product (LOX). Impure gaseous nitrogen 53 from the low pressure column 8 is warmed in subcooler 27 and main heat exchanger 3. The warmed impure nitrogen may be used in the air purification (not shown in the drawing). A liquid nitrogen product (LIN) may be withdrawn (55) from the top of the low pressure column. Gaseous nitrogen 56 from the top of the low pressure column 8 is warmed in subcooler 27 and main heat exchanger 3 and may be withdrawn as low-pressure product (LP-GAN) or taken via line 57 in order to be released to the atmosphere and/or used in the air purification (not shown in the drawing).

[0020] A gaseous, argon-containing oxygen fraction (the argon transition fraction) 58 is withdrawn from an intermediate height of the low pressure column 8 and fed to the bottom of the crude argon column 11. A mixture of the reflux liquid collecting in the bottom of the crude argon column 11 and the liquid purge stream 59 from the side condenser 10 is fed back to the low pressure column 8 by a transfer pump 61 via lines 60 and 62.

[0021] Crude argon from the top of the crude argon column 12 is introduced into pure argon column 13, producing liquid pure argon 64 at its bottom. The pure argon is taken as liquid to storage tanks, or alternatively may be internally compressed in argon pump 65, (pseudo-) evaporated in the main heat exchanger 3 and finally withdrawn as internally compressed gaseous argon (GAR-IC).

Claims

1. Process for cryogenic air separation in a distillation system comprising a high pressure column (7), a low pressure column (8), a side condenser (10) having an evaporation space and a crude argon distillation system comprising at least a first crude argon column (12), wherein

- feed air is compressed and purified,
- at least a portion of the purified feed air (1) is cooled in a MHE,
- at least a portion of the cooled feed is fed to the high pressure column (7),
- a first liquid oxygen stream (48) withdrawn from the low pressure column (8) is at least partially evaporated in the evaporation space of the side condenser (10) by indirect heat exchange with a heating medium (49),
- a first gaseous oxygen stream (51) produced by the evaporation of the first liquid oxygen stream is withdrawn from the evaporation space of the side condenser (10), warmed in the main heat exchanger (3) and finally withdrawn as a first gaseous oxygen product stream (LP-GOX),
- a liquid purge stream (59) is withdrawn from the side condenser,

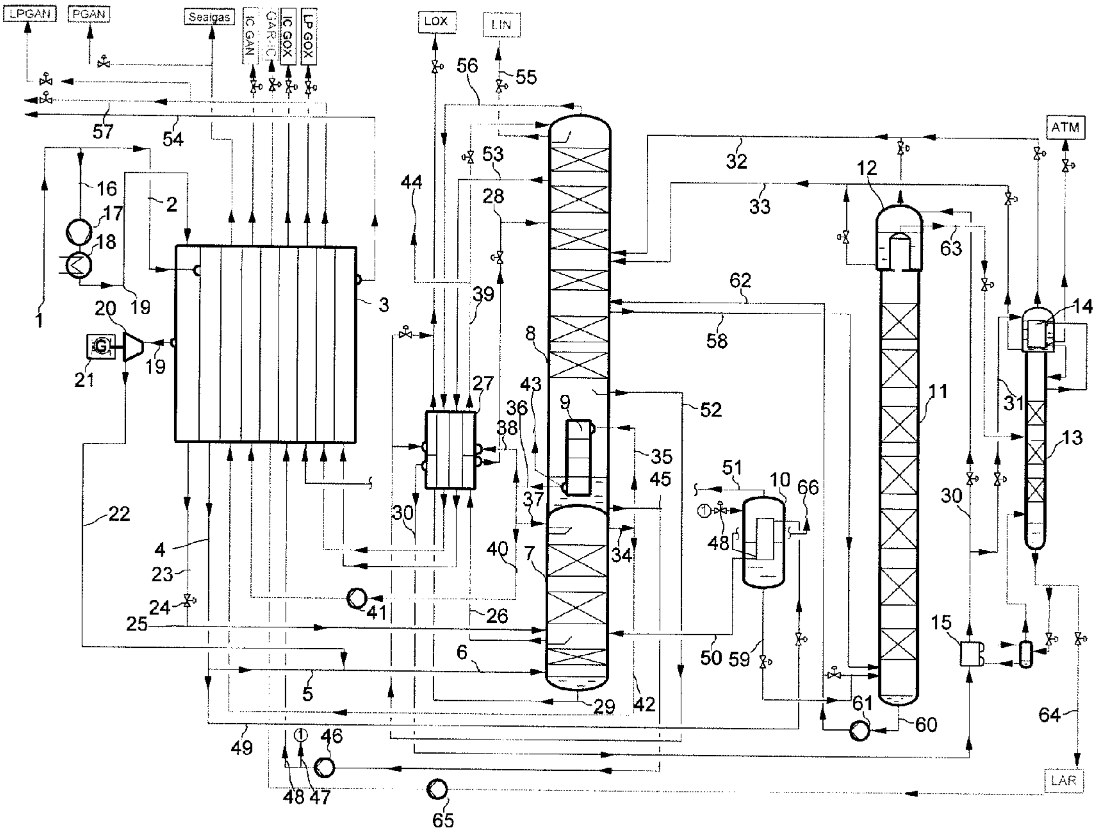
characterized in that

- the liquid purge stream (59) is introduced into the crude argon distillation system.

2. Process according to claim 1, the liquid purge stream being introduced into the bottom of the first crude argon column (12).

3. Process according to claim 1 or 2, a liquid return stream (60) from the bottom of the first crude argon column (12) is fed to the low pressure column (8) via a transfer pump (61).

4. Process according to any of claims 1 to 3, a second liquid oxygen stream (48) being withdrawn (45) from the low pressure column (8), the second liquid oxygen stream being pressurized (46) to pressure considerably above the low pressure column pressure, (pseudo-)evaporated and warmed in the main heat exchanger (3) and finally withdrawn as a second gaseous oxygen product stream (IC-GOX) having a higher pressure than the first gaseous oxygen product stream.


LPGAN
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EUROPEAN SEARCH REPORT

Application Number
EP 10 01 4198

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 May 2011	Göritz, Dirk

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 10 01 4198

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18-05-2011

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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