also used. These processes also operate with feed air approximately at the pressure of the first column and, in the majority of cases, a booster is also needed.

US-A-6 626 008 describes a heat pump cycle using a cold compressor to improve the distillation process for the production of oxygen of low purity for a double-vaporizer oxygen production process. A low air pressure, and a booster, are also representative of this type of process.

EP-A-1 972 872 describes means for improving the above processes, resorting to a cold compressor, in particular by introduction of all of the feed air flows into the columns at a temperature close to the temperature of the column at the point where the flow is introduced, with the aim of reducing the thermodynamic irreversibility of the system. However, it requires the addition of at least one additional compression stage.

The present invention is thus targeted at overcoming the disadvantages of these processes, in particular by introduction of all of the feed air flows into the columns at a temperature close to the temperature of the column at the point where the flow is introduced, with the aim of reducing the thermodynamic irreversibility of the system, without addition of an additional compression stage. The overall cost of the products of an oxygen production unit can thus be reduced. The main improvement is due to the use of a booster air compressor (BAC) in order to recycle the air once it has been used in order to recover the heat produced by the vaporization of a high-pressure liquid in the main heat exchanger.

All the percentages mentioned are percentages in moles.

A method according to the preamble of claim 1 is known from US6336345.

Summary

In a first aspect, the present disclosure provides a process for the separation of air by cryogenic distillation in a system of columns comprising a first column and a second column operating at a lower pressure than the first column, comprising the steps of: i) compression of all of the feed air in a first compressor up to a first outlet pressure of at most one bar greater than and preferably substantially equal to the pressure of the first column, ii) sending a first part of the air under the first outlet pressure to a second compressor, and compression of the air to a second outlet pressure, iii) cooling and condensation of at least a part of the air under the second outlet pressure in the heat exchanger, iv) sending an air gas flow under the first outlet pressure to the system of columns, without more forceful compression, and

separation of the air in the system of columns, v) withdrawal of the liquid from a column of the system of columns, pressurization of the liquid and vaporization of the liquid by a heat exchange in the heat exchanger, and vi) reduction in pressure of at least a fraction of the cooled and condensed air, from the second outlet pressure to at least a third pressure, at least partial vaporization of said air in the heat exchanger under the at least a third pressure, the third pressure being intermediate between the first outlet pressure and the second outlet pressure, optionally heating of said at least partially vaporized air in the heat exchanger, characterized in that at least a vaporized part of this air is sent to the second compressor in order to be compressed up to the second outlet pressure.

In a second aspect, the present disclosure provides an apparatus for separating air by cryogenic distillation in a system of columns comprising a first column and a second column operating at a lower pressure than the first column, additionally comprising: i) a first compressor for compressing the feed air to a first outlet pressure of at most one bar greater than the pressure of the first column, ii) means for sending purified and cooled air from the first compressor at the first pressure to the system of columns in order to be separated therein, iii) a second compressor and a means for sending a first part of the air under the first outlet pressure from the first compressor to the second compressor, in order to compress the air to a second outlet pressure, iv) a heat exchanger, in which at least a part of the air under the second outlet pressure is cooled and condensed, v) a means for removing the liquid from a column of the system of columns, a means for pressurizing the liquid, a means for sending the pressurized liquid to the heat exchanger and a means for removing the vaporized liquid from the heat exchanger, and vi) a means for reducing in pressure a fraction of the air cooled and condensed under the second outlet pressure, a means for sending said pressure-reduced air to the heat exchanger characterized in that it comprises a means for sending at least a part of said pressure-reduced air, which has been vaporized in the heat exchanger under at least a third pressure, intermediate between the first and second outlet pressures, from the heat exchanger to the second compressor, in order to compress it to the second outlet pressure.

According to the present disclosure, provision is made for a process for separating air by cryogenic distillation in a system of columns comprising a first column and a second column operating at a lower pressure than the first column, comprising the steps of:

i) compression of all of the feed air in a first compressor up to a first outlet pressure of at most one bar greater than the pressure of the first column, preferably substantially equal to the pressure of the first column,

ii) sending a first part of the air under the first outlet pressure to a second compressor, and compression of the air to a second outlet pressure,

iii) cooling and condensation of at least a part of the air under the second outlet pressure in a heat exchanger,

iv) withdrawal of the liquid from a column of the system of columns, pressurization of the liquid and vaporization of the liquid by heat exchange in the heat exchanger,

v) reduction in pressure of at least a fraction of the air cooled and condensed under the second outlet pressure down to an intermediate pressure between the first outlet pressure and the second outlet pressure, at least partial vaporization of said air in the heat exchanger, optionally heating of said air in the heat exchanger, characterized in that at least a part of this air is sent to the second compressor in order to be compressed up to the second outlet pressure.

Purified and cooled air is sent from the first compressor to the system of columns in order to be separated therein.

According to other optional embodiments of the disclosure, which can be combined with one another:

- the reduction in pressure is carried out in at least one valve,
- the reduction in pressure is carried out in at least one turbine and produces work,
- the temperature of the at least a fraction before reduction in pressure is less than the sum of the temperature of the vaporization of the liquid and the minimum temperature approach in the heat exchanger,
- the second compressor is a multistage compressor,
- said at least a third pressure is at least the inlet pressure of one of the stages of the second compressor,
- a stage of the second compressor is driven by a device for the reduction in pressure of a fluid of the process,
- the inlet temperature of the device for the reduction in pressure is less than ambient temperature,
- at least one stage of the second compressor has a suction temperature which is less than ambient temperature,
- the suction temperature is greater than the vaporization temperature of the liquid, but is close to it,
- the liquid is a flow enriched in oxygen,
- the liquid is a flow enriched in nitrogen,
- the production flow of the liquid product or products is not greater than 10% of the feed air, preferably is not greater than 5% of the feed air.

According to another embodiment of the disclosure, provision is made for an apparatus for separating air by cryogenic distillation in a system of columns comprising a first column and a second column operating at a lower pressure than the first column, additionally comprising:

i) a first compressor for compressing the feed air up to a first outlet pressure of at least one bar greater than the pressure of the first column, preferably substantially equal to the pressure of the first column,

ii) a second compressor and a means for sending a first part of the air under the first outlet pressure to the second compressor, in order to compress the air up to a second outlet pressure,

iii) a heat exchanger, in which at least a part of the air under the second outlet pressure is cooled and condensed,

iv) a means for withdrawing the liquid from a column of the system of columns, a means for pressurizing the liquid, a means for sending the pressurized liquid to the heat exchanger and a means for withdrawing the vaporized liquid from the heat exchanger,

v) a means for reducing in pressure a fraction of the air cooled and condensed under the second outlet pressure, a means for sending said air fluid to the heat exchanger, a means for sending at least a part of said air which has been vaporized in the heat exchanger under at least a third pressure, intermediate between the first and second outlet pressures, to the second compressor in order to be compressed up to the second outlet pressure, and

vi) means for sending purified and cooled air to the system of columns in order to be separated therein.

According to other optional embodiments of the disclosure:

- the first storage tank and optionally the second storage tank is independent of the system of columns,
- the apparatus comprises a turbine for reduction in pressure of the fraction of auxiliary flow compressed in the second compressor.

Detailed description

The invention will now be described in more detail with reference to figures 3, 5 and 6, which are schemes of circulation of the fluids representing processes for the cryogenic separation of air according to the invention, and figure 4, which is a heat exchange diagram for the exchanger 5 of figure 3.