[Patent Documents]

[0003]

[Patent Document 1] US 4,222,756

[Patent Document 2] JP 8-61844 A

[Summary of the Invention]

[Problem to be Solved by the Invention]

[0004]

It is difficult to apply the method disclosed in Patent Document 1, in which a gas containing oxygen drawn from a condenser portion of a rectification column is utilized as a cold source in order to improve energy efficiency, to a method for producing not only nitrogen but also argon. Furthermore, although the method disclosed in Patent Document 1 makes it possible to produce nitrogen, there is no mention of producing argon.

However, recent years have seen increasing demand for extracting not only nitrogen but also argon.

[0005]

In light of the circumstances described above, the aim of the present invention lies in providing a method for producing high-purity nitrogen and argon with high energy efficiency by utilizing the cold of an oxygen-containing gas, and also an apparatus employed in said method.

[Means for Solving the Problem]

[0006]

In one aspect, there is provided a method for producing product nitrogen gas and product argon, comprising:

a cooling step in which raw air from which predetermined impurities have been removed is cooled;

a raw air introduction step in which the raw air cooled in the cooling step is introduced into a first rectification column;

a first oxygen-enriched liquid introduction step in which an oxygen-enriched liquid drawn from a column bottom portion of the first rectification column is introduced into a second rectification column;

a second oxygen-enriched liquid introduction step in which at least a portion of the oxygen-enriched liquid drawn from the column bottom portion of the first rectification column is introduced into a second condenser disposed in a third rectification column;

a nitrogen-containing liquid introduction step in which a nitrogen-containing liquid condensed in a first condenser is introduced as a reflux liquid at an upper portion of the second rectification column;

an expansion step in which at least a portion of a mixed gas is expanded to generate cold, after being made to release cold by means of heat exchange with raw air in a main heat exchanger, the mixed gas comprising an intermediate portion gas drawn from an intermediate portion of the second rectification column and a condenser gas drawn from the first condenser which is configured to perform heat exchange between a gas accumulated in a column top portion of the first rectification column, and a liquid accumulated in a column bottom portion of the second rectification column, and is made to release further cold by means of reintroduction into the main heat exchanger;

an argon-containing gas introduction step in which an argon-containing gas drawn from a lower portion of the second rectification column is introduced into the third rectification column;

a product nitrogen gas drawing step in which product nitrogen gas is drawn from a column top portion of the second rectification column; and

a product argon drawing step in which product argon is drawn from the intermediate portion of the third rectification column.

In another aspect, there is provided An apparatus for producing product nitrogen gas and product argon, comprising:
a main heat exchanger for cooling raw air from which predetermined impurities have been removed;
a first rectification column into which the cooled raw air is introduced;
a second rectification column from which product nitrogen gas is drawn;
a third rectification column from which product argon is drawn;
a first condenser configured to perform heat exchange between a gas accumulated in a column top portion of the first rectification column, and a liquid accumulated in a column bottom portion of the second rectification column;
a nitrogen-containing liquid introduction pipe for introducing at least a portion of a nitrogen-containing liquid condensed in the first condenser into the second rectification column as a reflux liquid;
an argon-containing gas introduction pipe for introducing an argon-containing gas into the third rectification column from a lower portion of the second rectification column;

an argon-containing liquid drawing pipe for introducing an argon-containing liquid into the second rectification column from a column bottom portion of the third rectification column;
a condenser gas drawing pipe for drawing a condenser gas from a gas-phase portion of the first condenser;
an intermediate portion gas drawing pipe for drawing an intermediate portion gas from an intermediate portion of the second rectification column;
an expansion turbine for expanding and cooling a mixed gas comprising the condenser gas and the intermediate portion gas, after said mixed gas has been made to pass through the main heat exchanger; a pipe for introducing into the main heat exchanger a gas expanded and cooled in the expansion turbine;
a product nitrogen gas drawing pipe for drawing the product nitrogen gas from the second rectification column; and
a product argon drawing pipe for drawing the product argon from an intermediate portion of the third rectification column.

(Invention 1)
A method for producing product nitrogen gas and product argon gas according to the present invention comprises:
a cooling step in which raw air from which predetermined impurities have been removed is cooled;

[Document Name] PATENT CLAIMS

[Claim 1]
A method for producing product nitrogen gas and product argon, comprising:
a cooling step in which raw air from which predetermined impurities have been removed is cooled;
a raw air introduction step in which the raw air cooled in the cooling step is introduced into a first rectification column;
a first oxygen-enriched liquid introduction step in which an oxygen-enriched liquid drawn from a column bottom portion of the first rectification column is introduced into a second rectification column;
a second oxygen-enriched liquid introduction step in which at least a portion of the oxygen-enriched liquid drawn from the column bottom portion of the first rectification column is introduced into a second condenser disposed in a third rectification column;
a nitrogen-containing liquid introduction step in which a nitrogen-containing liquid condensed in a first condenser is introduced as a reflux liquid at an upper portion of the second rectification column;
an expansion step in which at least a portion of a mixed gas is expanded to generate cold, after being made to release cold by means of heat exchange with raw air in a main heat exchanger, the mixed gas comprising an intermediate portion gas drawn from an intermediate portion of the second rectification column and a condenser gas drawn from the first condenser which is configured to perform heat exchange between a gas accumulated in a column top portion of the first rectification column, and a liquid accumulated in a column bottom portion of the second rectification column, and is made to release further cold by means of reintroduction into the main heat exchanger;
an argon-containing gas introduction step in which an argon-containing gas drawn from a lower portion of the second rectification column is introduced into the third rectification column;

a product nitrogen gas drawing step in which product nitrogen gas is drawn from a column top portion of the second rectification column; and

a product argon drawing step in which product argon is drawn from the intermediate portion of the third rectification column.

[Claim 2]

An apparatus for producing product nitrogen gas and product argon, comprising:

a main heat exchanger for cooling raw air from which predetermined impurities have been removed;

a first rectification column into which the cooled raw air is introduced;

a second rectification column from which product nitrogen gas is drawn;

a third rectification column from which product argon is drawn;

a first condenser configured to perform heat exchange between a gas accumulated in a column top portion of the first rectification column, and a liquid accumulated in a column bottom portion of the second rectification column;

a nitrogen-containing liquid introduction pipe for introducing at least a portion of a nitrogen-containing liquid condensed in the first condenser into the second rectification column as a reflux liquid;

an argon-containing gas introduction pipe for introducing an argon-containing gas into the third rectification column from a lower portion of the second rectification column;

an argon-containing liquid drawing pipe for introducing an argon-containing liquid into the second rectification column from a column bottom portion of the third rectification column;

a condenser gas drawing pipe for drawing a condenser gas from a gas-phase portion of the first condenser;

an intermediate portion gas drawing pipe for drawing an intermediate portion gas from an intermediate portion of the second rectification column;
an expansion turbine for expanding and cooling a mixed gas comprising the condenser gas and the intermediate portion gas, after said mixed gas has been made to pass through the main heat exchanger; a pipe for introducing into the main heat exchanger a gas expanded and cooled in the expansion turbine;
a product nitrogen gas drawing pipe for drawing the product nitrogen gas from the second rectification column; and
a product argon drawing pipe for drawing the product argon from an intermediate portion of the third rectification column.

[Claim 3]
Apparatus for producing product nitrogen gas and product argon as claimed in claim 2, comprising:
an oxygen-enriched liquid drawing pipe for drawing, from a column bottom portion of the first rectification column, an oxygen-enriched liquid accumulated in the column bottom portion of the first rectification column;
a second oxygen-enriched liquid introduction pipe for introducing, into a second condenser disposed in the third rectification column, the oxygen-enriched liquid drawn from the oxygen-enriched liquid drawing pipe; and
a third oxygen-enriched liquid introduction pipe for introducing the oxygen-enriched liquid drawn from the second condenser into the second rectification column.

[Claim 4]
The apparatus for producing product nitrogen gas and product argon as claimed in claim 3, wherein the third oxygen-enriched liquid introduction pipe introduces the oxygen-enriched liquid in a gaseous state from a gas-phase portion of the second condenser into the second rectification column.

[Claim 5]