

【DESCRIPTION】**【Invention Title】**

APPARATUS FOR PRODUCING HIGHER-PURITY CARBON
DIOXIDE FOR RECOVERING CARBON DIOXIDE FROM WASTE GAS
5 CONTAINING FLAMMABLE IMPURITIES, AND METHOD FOR
RECOVERING HIGHER-PURITY CARBON DIOXIDE USING SAME

【Technical Field】

The present invention relates to a carbon dioxide high-purity purification
apparatus for recovering carbon dioxide from exhaust gas containing combustible
10 impurities and a method for recovering high-purity carbon dioxide using the same,
and more particularly to an apparatus for efficiently burning exhaust gas
containing combustible impurities using pure oxygen, thereby producing high-
purity carbon dioxide, and a method for recovering high-purity carbon dioxide
using the same.

15 **【Background Art】**

Recently, various combustion technologies have been applied to treat waste
gas exhausted from production processes for various products including chemical
processes. Such technologies employ a direct combustion method, a catalytic
combustion method, a regenerative combustion method, etc. Most combustion
20 methods are adapted to treat volatile organic compound (VOC) exhausted in a state
of being mixed with general air. The VOC reacts with oxygen contained in the gas
mixture during a combustion process, so that it is changed into carbon dioxide and
water, which are, in turn, vented to the atmosphere.

However, when the carbon dioxide content of the exhaust gas is 90% or
25 more, as in exhaust gas generated in an only MEG advanced (OMEGA) process,
treatment of such exhaust gas using a general combustion method may cause
exhaust of a large amount of CO₂ to the atmosphere, thereby promoting global
warming.

The OMEGA process (Licenser: Shell Company) is a new process for

producing ethylene glycol (EG), and the world's first commercial production facilities thereof were installed in Korea in 2008, and are in operation. The OMEGA process has differences from a conventional EG production process (Licensor: Scientific Design Company), as follows.

5 In the conventional process, in addition to mono-ethylene glycol (MEG) intended to be produced, di-ethylene glycol (DEG), tri-ethylene glycol (TEG), poly-ethylene glycol (PEG) or the like are produced. For this reason, additional expenses are required to purify the products. In the OMEGA process, however, MEG alone is produced. Thus, the OMEGA process has an advantage of very high
10 productivity. Furthermore, the OMEGA process requires reduced use of various facilities. In addition, the amount of waste water generated in the OMEGA process is reduced by 30%, as compared to the conventional process. Accordingly, the OMEGA process is deemed a process having high competitiveness. In the future, conventional processes will be gradually replaced by the OMEGA process.

15 However, the OMEGA process has the following disadvantages, as compared to the conventional process.

 Waste gas exhausted from the conventional process is directly usable after recovery because the CO₂ content of the waste gas is 99% or more. On the other hand, gas exhausted from the OMEGA process contains 97% CO₂ with the balance
20 being ethylene oxide (EO), acetaldehyde, ethylene, methane and the like. However, although the waste gas exhausted from the OMEGA process contains CO₂ in high concentration, it still contains harmful substances such as VOC. Since the harmful substances emit offensive odors, it is difficult to directly recover the exhaust gas in order to use CO₂ contained therein. Furthermore, separation and recovery of
25 CO₂ alone may be expensive and may involve technical difficulty.

 In fact, even in the design proposed by the licensor of the OMEGA process, Shell Company, exhaust gas from the OMEGA process is fed to a waste heat boiler, to be vented to the atmosphere after being subjected to incineration. However, when exhaust gas from the OMEGA process is vented to the atmosphere after being
30 combusted using a waste heat boiler, a large amount of CO₂ is vented to the atmosphere. This is inconsistent with the basis of the recent low-carbon green

growth policy. Furthermore, there may be problems of waste of regenerable resources and promotion of global warming.

A pure oxygen combustion boiler, into which active research is being conducted, is a technology using oxygen contained in air while excluding nitrogen.
5 This technology is used to recover CO₂ exhausted from a glass melting furnace, a steel heating furnace, a boiler, or the like, which mainly uses fossil fuels.

However, since fossil fuels and pure oxygen are continuously supplied to continuously maintain flames of a burner in this technology, there may be a problem in the durability of materials due to high flame temperature (3,050°K). In
10 particular, when waste gas is vented under high pressure, as in the above-mentioned OMEGA process, the burner may not be ignited due to high pressure of the combustion furnace in a combustion procedure. Under these circumstances, the pure oxygen combustion technology, which is used in a steel heating furnace, a boiler, or the like, as mentioned above, is difficult to be applied to the above-
15 mentioned process involving high exhaust pressure.

【Disclosure】

【Technical Problem】

Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a carbon dioxide
20 high-purity purification apparatus capable of achieving combustion even in a low temperature range, and a method of recovering high-purity carbon dioxide using the apparatus without causing a problem in the durability of materials even in the combustion of exhaust gas using pure oxygen.

Another object of the present invention is to provide a method of safely
25 and effectively recovering a large amount of CO₂ generated in a process in which high pressure is generated during combustion, by providing a carbon dioxide high-purity purification apparatus including a combustion furnace, in which a burner is not required to be in a continuously ignited state.

Another object of the present invention is to provide an apparatus capable
30 of safely high-purity purifying and recovering CO₂ generated in an only MEG

advanced (OMEGA) process.

Still another object of the present invention is to provide an economical and environmentally friendly process capable of effectively recovering CO₂ generated in an OMEGA process to enable use of the recovered CO₂.

5 **【Technical Solution】**

In accordance with an aspect of the present invention, the above and other objects can be accomplished by the provision of a carbon dioxide high-purity purification method including: high-purity purifying carbon dioxide (CO₂) of waste gas containing 90% or more high-concentration CO₂ with a
10 balance being volatile organic compound (VOC) and oxygen, using a pure oxygen combustion process, until the waste gas has an oxygen concentration of 1.2 to 2% and a VOC concentration of 10,000 to 20,000 PPM with a balance being CO₂.

The waste gas may be waste gas exhausted from an only MEG advanced
15 (OMEGA) process.

In accordance with another aspect of the present invention, there is provided a carbon dioxide high-purity purification apparatus including: a) a process gas input unit including a pressure reduction valve for reducing a pressure of input gas to 1.0 kg/cm² or less, a pure oxygen supplier for
20 supplying pure oxygen, an assistant fuel supplier for supplying assistant fuels to the input gas, a fan for increasing an internal temperature of a process gas combustion unit, an inlet O₂ detector for measuring an O₂ concentration and a volatile organic compound (VOC) concentration of the input gas, and a lower explosive limit (LEL) detector; b) the process gas combustion unit including a
25 burner for increasing an internal temperature of the combustion unit, a combustion chamber for burning VOC contained in the input gas, a heat storage layer for storing combustion heat, a temperature detector for measuring an internal temperature of the combustion chamber, and a bypass damper for preventing an excessive increase in the internal temperature of the
30 combustion chamber; and c) a combusted gas discharge unit including an

outlet O₂ detector and a temperature detector for measuring an O₂ concentration and a temperature of combusted gas, respectively, a recycling fan for again supplying the combusted gas to the process gas input unit, and a heat exchanger.

5 The carbon dioxide high-purity purification apparatus may further include a controller for controlling opening/closing of a valve to control a supply amount of O₂ in accordance with a signal from the input O₂ detector.

 The assistant fuels may be one of liquefied petroleum gas (LPG), liquefied natural gas (LNG), methane, and butane.

10 The carbon dioxide high-purity purification apparatus may further include a controller for controlling opening/closing of a valve to control a supply amount of assistant fuels in accordance with a signal from the LEL detector and a signal from the temperature detector.

 The temperature increasing fan and the burner may operate only when
15 the internal temperature of the combustion unit is to be increased, and may no longer operate when a process gas is introduced into the combustion unit after the internal temperature of the combustion unit reaches a target temperature.

 The combustion unit may be one of a regenerative thermal oxidizer (RTO), a regenerative catalytic oxidizer (RCO), a thermal oxidizer (TO), and
20 a catalytic thermal oxidizer (CTO).

 The carbon dioxide high-purity purification apparatus may further include a controller for controlling opening/closing of the bypass damper in accordance with a signal from the temperature detector installed in the combustion chamber.

25 The carbon dioxide high-purity purification apparatus may further include a controller for controlling operation of the recycling fan in accordance with a signal from the LEL detector and a signal form the temperature detector.

 The carbon dioxide high-purity purification apparatus may further
30 include a moisture remover and a strainer, which are installed upstream of the combustion unit, to prevent moisture and dregs contained in waste gas from

being introduced into the combustion unit.

External air introduced through the temperature increasing fan may be used to cool an inner disk included in the bypass damper.

When a temperature increase is completed, operation of the burner
5 may be stopped, and a back-fire preventing valve may be opened to introduce waste gas, which has not been subjected to pressure reduction, into the burner so as to prevent back-fire and explosion.

The carbon dioxide high-purity purification apparatus may further include a personal computer (PC) system for controlling the detectors, to
10 control the oxygen concentration measured by the outlet O₂ detector, the temperature measured by the temperature detector, and the VOC concentration measured by the LEL detector to be maintained within predetermined ranges thereof, respectively.

The predetermined ranges may correspond to an oxygen concentration
15 range of 1.2 to 2%, a temperature of 700 to 880°C, and a VOC concentration of 10,000 to 20,000 PPM, respectively.

【Advantageous Effects】

In accordance with the present invention, it may be possible to effectively remove combustible impurities from exhaust gas containing the combustible
20 impurities, and thus to prevent harmful substances from being discharged to the atmosphere.

Also, in accordance with the present invention, an economical process is provided because a large amount of CO₂ is recovered from exhaust gas generated in a production process. It may also be possible to prevent environmental
25 pollution caused by discharge of carbon dioxide.

In addition, in accordance with the present invention, a high-purity purification method for CO₂ generated in an OMEGA process is provided, so that it may be possible to eliminate drawbacks of the OMEGA process, and thus to safely and efficiently use the OMEGA process.

【Description of Drawings】

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

5 FIG. 1 is a diagram illustrating a configuration of a carbon dioxide high-purity purification apparatus according to the present invention.

<Description of Reference Numerals to Drawings>

	100: OMEGA Process	110: Emergency Venting Valve
	111: Automatic Process Gas Introduction Valve	
10	112: Pressure Reduction Valve	
	120: Pure Oxygen Reservoir	121: Pure Oxygen Supply Valve
	122: Mixer Box	130: External Air Suction Fan
	131: LEL Detector	132: Inlet O ₂ Detector
	133: Rupture Disk	134: Inlet Duct
15	140: Combustion Unit	141: Heat Storage Layer
	142: Temperature Detector	143: Outlet O ₂ Detector
	144: Outlet Duct	145: Bypass Damper
	146: Bypass Duct	150: Distribution plate Reducer
	160: Purge Fan	170: Recycling Fan
20	180: Heat Exchanger	
	181: Recovery (Recycling) Feeding Valve	
	182: Atmosphere Vent Valve	200: Assistant Fuel Reservoir
	201: Assistant Fuel Shut-off Valve	210: external air suction fan
	211: Back-Fire Preventing Valve	212: External Air Supply Valve
25	220: Assistant Fuel Supply Valve	230: Burner
	300: PC system	

【Best Mode】

In accordance with the present invention, an apparatus for high-purity purifying carbon dioxide from process exhaust gas containing combustible
30 impurities, using pure oxygen, includes: a combustion unit including a body and a

combustion chamber defined in the body to burn volatile organic compound (VOC) contained in the process exhaust gas at a temperature range of 300 to 990°C; an external air suction fan for increasing an internal temperature of the combustion unit; a burner for increasing the internal temperature of the combustion unit to a target temperature ranging from 300°C to 990°C; a pressure reduction valve for reducing a pressure of the process exhaust gas to 1.0 kg/cm² or less; a mixer for mixing pure oxygen with the process exhaust gas; an O₂ detector for measuring an oxygen concentration and an O₂ supplier provided with a valve to be controlled in accordance with the O₂ detector; a lower explosive limit (LEL) detector for measuring a VOC concentration of the process exhaust gas; an assistant fuel supplier controlled for supply of assistant fuels in accordance with the internal temperature of the combustion chamber and the value measured by the LEL detector; a recycling fan for again feeding combusted gas so as to prevent overheating of the combustion unit; and a heat exchanger for removing moisture from the combusted gas.

Hereinafter, an exemplary embodiment of the present invention relating to a CO₂ high-purity purification apparatus using pure oxygen will be described in detail.

This embodiment will be described in conjunction with the case in which exhaust gas containing combustible impurities to be treated is gas exhausted from an OMEGA process 100. However, the present invention may be applied to any processes, from which exhaust gas containing 10% or less combustible impurities and 90% or more carbon dioxide is generated.

FIG. 1 is a diagram illustrating a configuration of a carbon dioxide high-purity purification apparatus for burning waste gas exhausted from a production process in accordance with the present invention. Referring to FIG. 1, a combustion unit 140 is illustrated. The combustion unit 140 includes a burner 230, which is ignited using assistant fuels (liquefied petroleum gas (LPG), liquefied natural gas (LNG), methane, butane, or the like), in order to increase the internal temperature of the combustion unit 140 during operation of the combustion unit 140. Oxygen required for combustion is supplied to the combustion unit 140 by external air suction fans 130 and 210. The combustion unit 140 is configured to increase the internal temperature thereof to a target temperature (300 to 990°C).

As the combustion unit 140, a regenerative thermal oxidizer (RTO), a regenerative catalytic oxidizer (RCO), a thermal oxidizer (TO), a catalytic thermal oxidizer (CTO), or the like may be used.

5 When the internal temperature of the combustion unit 140 is increased to a target temperature (300 to 990°C), operation of the burner 230 is stopped. At the same time, an external air supply valve 212 connected to the external air suction fan 210, and an automatic process gas introduction valve 111 is opened. Accordingly, waste gas exhausted from an only MEG advanced (OMEGA) process 100 is fed to the combustion unit 140.

10 In this case, the external air sucked through the external air suction fan 210 is exclusively used to cool an inner disk included in a bypass damper 145 as the external air supply valve 212 is closed. Thus, it may be possible to avoid overheating of the bypass damper 145, which is exposed to high temperature, and thus to prevent the bypass damper 145 from malfunctioning.

15 In order to reduce the pressure of the waste gas fed to the combustion unit 140 to 1.0 kg/cm² or less, a pressure reduction valve 112 is installed in an inlet duct 134 for the exhaust gas. Accordingly, stable operation of the combustion unit 140 is achieved. In order to protect process production facilities from increased pressure, a rupture disk 133 is provided to vent waste gas to the atmosphere when
20 the pressure of the inlet duct 134 reaches 1.9 kg/cm² or more. When malfunction of the combustion unit 140 is sensed, the automatic process gas introduction valve 111 is automatically closed as an automatic stop mode is activated. Simultaneously, an emergency valve 110 is opened to achieve emergency venting of exhaust gas before introduction of exhaust gas into the combustion unit 140. Thus,
25 safety is secured.

Although not shown, a moisture remover and a strainer are installed upstream of the combustion unit 140 in order to prevent moisture and dregs contained in the waste gas from being introduced into the combustion unit 140.

30 When operation of the burner 230 is stopped after completion of the temperature increase, combusted gas may function as an igniter for the burner 230 due to the pressure of the waste gas introduced into the combustion unit 140, so that

there may be a danger of explosion. To this end, a back-fire preventing valve 211 is opened to introduce waste gas, which has not been subjected to pressure reduction, into the burner 230, and thus to prevent back-fire and explosion.

When operations of the burner 230 and external air suction fans 130 and
5 210 are stopped, pure oxygen is supplied for combustion of waste gas exhausted from the process, through an automatic pure oxygen supply valve 121. The supplied pure oxygen is mixed with the waste gas in a mixer box 122. The supply amount of pure oxygen is automatically adjusted by the automatic pure oxygen supply valve 121 in accordance with a measurement value obtained by an inlet O₂
10 detector 132, which measures O₂ content of the gas mixture produced in the mixer box 122. Also, the supply amount of assistant fuels supplied through an assistant fuel supply valve 220 is adjusted in accordance with the volatile organic compound (VOC) concentration of the waste gas measured by a lower explosive limit (LEL) detector 131 and the temperature of a combustion chamber.

15 The waste gas introduced into the combustion unit 140 is increased in temperature as it passes through a heat storage layer 141. Thereafter, the waste gas is combusted at an internal temperature of the combustion unit 140 (300 to 990°C), so that high-purity CO₂ alone is discharged into an outlet duct 144. Waste gas may remain in the heat storage layer 141 without being introduced into the interior of the
20 combustion unit 140 during heat storage and discharge procedures of the combustion unit 140, and may be discharged in a non-treated state. In this case, combustion efficiency is degraded. In order to solve this problem, purge air is supplied by a purge fan 160 to introduce non-treated gas left in the heat storage layer 141 into the inlet duct 134 through forcible discharge. Thus, optimal treatment
25 efficiency is obtained.

When the internal temperature of the combustion unit 140 is increased to a predetermined temperature or above due to high VOC concentration of waste gas introduced into the combustion unit 140, the bypass damper 145 is automatically controlled in order to stably maintain the internal temperature of the combustion unit
30 140 at a desired temperature. The high-temperature gas exhausted from the combustion unit 140 is cooled through a heat exchanger 180.

A recycle fan 170 is operated in accordance with the VOC concentration of waste gas detected by the LEL detector 131 and the temperature of the combustion chamber, in order to avoid overheating of the combustion unit 140. A part of the treated high-temperature high-purity CO₂ gas is again introduced into the inlet duct 134, to be mixed with waste gas. In this case, pre-heating and VOC concentration dilution effects are obtained. Accordingly, smooth and stable combustion is achieved.

The high-purity CO₂ discharged from the combustion unit 140 passes around the heat exchanger 180, for cooling thereof and moisture removal therefrom. The high-purity CO₂ emerging from the heat exchanger 180 is fed to a recovery (recycling) facility. In this case, the heat exchanger 180 may also be used to increase the temperature of waste gas introduced into the combustion unit 140.

The high-purity CO₂ is fed to the high-purity CO₂ recovery facility only when the oxygen concentration measured by an outlet O₂ detector 143, the temperature measured by a temperature detector 142, and the VOC concentration measured by the LEL detector 131 fall within normal ranges thereof (Oxygen concentration measured by the outlet O₂ detector 143: 1.2 to 2%; Temperature measured by the temperature detector 142: 700 to 880°C; and VOC concentration measured by the LEL detector 131: 10,000 to 20,000 ppm), respectively. The normal ranges are appropriate ranges enabling recovery and recycling of carbon dioxide. A personal computer (PC) system 300, which can control detectors, is installed in order to control the concentrations and temperature to fall within respective normal ranges thereof. When the concentrations and temperature fall within the normal ranges thereof, respectively, a recovery (recycling) feeding valve 181 is opened to feed the high-purity CO₂ to the recovery facility. On the other hand, when the concentrations and temperature do not fall within respective normal ranges thereof, an automatic vent valve 182 is opened to vent the treated gas to the atmosphere.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing

from the scope and spirit of the invention as disclosed in the accompanying claims.

【CLAIMS】

【Claim 1】 A carbon dioxide high-purity purification method comprising:

high-purity purifying carbon dioxide (CO₂) of waste gas containing 90% or more high-concentration CO₂ with a balance being volatile organic compound (VOC) and oxygen, using a pure oxygen combustion process, until the waste gas has an oxygen concentration of 1.2 to 2% and a VOC concentration of 10,000 to 20,000 ppm with a balance being CO₂.

【Claim 2】 The carbon dioxide high-purity purification method according to claim 1, wherein the waste gas is waste gas exhausted from an only MEG advanced (OMEGA) process.

【Claim 3】 A carbon dioxide high-purity purification apparatus comprising:

a) a process gas input unit comprising

a pressure reduction valve for reducing a pressure of input gas to 1.0 kg/cm² or less,

a pure oxygen supplier for supplying pure oxygen,

an assistant fuel supplier for supplying assistant fuels to the input gas,

a fan for increasing an internal temperature of a process gas combustion unit,

an inlet O₂ detector for measuring an O₂ concentration and a volatile organic compound (VOC) concentration of the input gas, and

a lower explosive limit (LEL) detector;

b) the process gas combustion unit comprising

a burner for increasing an internal temperature of the combustion unit,

a combustion chamber for burning VOC contained in the input gas,

a heat storage layer for storing combustion heat,

a temperature detector for measuring an internal temperature of the combustion chamber, and

a bypass damper for preventing an excessive increase in the internal temperature of the combustion chamber; and

5 c) a combusted gas discharge unit comprising

an outlet O₂ detector and a temperature detector for measuring an O₂ concentration and a temperature of combusted gas, respectively,

a recycling fan for again supplying the combusted gas to the process gas input unit, and

10 a heat exchanger.

【Claim 4】 The carbon dioxide high-purity purification apparatus according to claim 3, further comprising:

a controller for controlling opening/closing of a valve to control a supply amount of O₂ in accordance with a signal from the input O₂ detector.

15 **【Claim 5】** The carbon dioxide high-purity purification apparatus according to claim 3, wherein the assistant fuels are one of liquefied petroleum gas (LPG), liquefied natural gas (LNG), methane, and butane.

【Claim 6】 The carbon dioxide high-purity purification apparatus according to claim 3, further comprising:

20 a controller for controlling opening/closing of a valve to control a supply amount of assistant fuels in accordance with a signal from the LEL detector and a signal from the temperature detector.

【Claim 7】 The carbon dioxide high-purity purification apparatus according to claim 3, wherein the temperature increasing fan and the burner operate only when the internal temperature of the combustion unit is to be increased, and no longer operate when a process gas is introduced into the combustion unit after the internal temperature of the combustion unit reaches a target temperature.

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【Claim 8】 The carbon dioxide high-purity purification apparatus according to claim 3, wherein the combustion unit is one of a regenerative thermal oxidizer (RTO), a regenerative catalytic oxidizer (RCO), a thermal oxidizer (TO), and a catalytic thermal oxidizer (CTO).

5 【Claim 9】 The carbon dioxide high-purity purification apparatus according to claim 3, further comprising:

 a controller for controlling opening/closing of the bypass damper in accordance with a signal from the temperature detector installed in the combustion chamber.

10 【Claim 10】 The carbon dioxide high-purity purification apparatus according to claim 3, further comprising:

 a controller for controlling operation of the recycling fan in accordance with a signal from the LEL detector and a signal from the temperature detector.

15 【Claim 11】 The carbon dioxide high-purity purification apparatus according to claim 3, further comprising:

 a moisture remover and a strainer, which are installed upstream of the combustion unit, to prevent moisture and dregs contained in waste gas from being introduced into the combustion unit.

20 【Claim 12】 The carbon dioxide high-purity purification apparatus according to claim 3, wherein external air introduced through the temperature increasing fan is used to cool an inner disk included in the bypass damper.

25 【Claim 13】 The carbon dioxide high-purity purification apparatus according to claim 3, wherein, when a temperature increase is completed, operation of the burner is stopped, and a back-fire preventing valve is opened to introduce waste gas, which has not been subjected to pressure reduction, into the burner so as to prevent back-

fire and explosion.

【Claim 14】 The carbon dioxide high-purity purification apparatus according to claim 3, further comprising:

5 a personal computer (PC) system for controlling the detectors, to control the oxygen concentration measured by the outlet O₂ detector, the temperature measured by the temperature detector, and the VOC concentration measured by the LEL detector to be maintained within predetermined ranges thereof, respectively.

【Claim 15】 The carbon dioxide high-purity purification apparatus according to claim 14, wherein the predetermined ranges correspond to an oxygen concentration
10 range of 1.2 to 2%, a temperature of 700 to 880°C, and a VOC concentration of 10,000 to 20,000 ppm, respectively.