HYDROCARBON FEEDSTOCK GASIFIER

Inventors: Yoshinori Koyama, Tokyo (JP); Takao Hashimoto, Tokyo (JP); Katsuhiro Ota, Tokyo (JP); Hiromi Ishii, Tokyo (JP); Shozo Kaneko, Tokyo (JP)

Appl. No.: 13/819,850
PCT Filed: Jan. 24, 2012
PCT No.: PCT/JP12/51467
§ 371(c)(1), (2), (4) Date: Feb. 28, 2013

Foreign Application Priority Data
Mar. 17, 2011 (JP) ................................. 2011-059518

Publication Classification
Int. Cl.
C10J 3/72 (2006.01)

U.S. Cl.
CPC ........................................ C10J 3/723 (2013.01)
USPC ........................................ 48/99, 48/101

ABSTRACT
A hydrocarbon feedstock gasifier (gasifier) is provided with: a heat transmission surface disposed within a gasification region of a gasifier configured from a pressure vessel for generating produced gas by partially oxidizing coal which is a hydrocarbon feedstock; a heat exchanger disposed on the path of a circulation line for a circulation medium circulating within the heat transmission surface and for exchanging the heat of the circulation medium; and a circulation pump for circulating the circulation medium.
FIG. 2

- **Methanation**: CO + 3H₂ → CH₄ + H₂O
- **Methanol Synthesis**: CO + 2H₂ → CH₃OH

Graph shows the molar ratio of H₂/CO against temperature (°C) ranging from 0 to 1500°C.
FIG. 3

GASIFIER

GAS TURBINE COMBUSTION DEVICE

GAS REFINEMENT UNIT

CO SHIFT REACTOR

METHANOL SYNTHESIS UNIT

METHANE SYNTHESIS UNIT

11

10A

12

30

31

33

34

35

36

41

42

43

44

G

LIQUID FUEL (METHANOL)

GAS FUEL (SYNTHETIC NATURAL GAS: SNG)
METHANATION: CO + 3H₂ → CH₄ + H₂O
METHANOL
SYNTHESIS: CO + 2H₂ → CH₃OH
H₂/CO (STEAM 25%)

FIG. 8-1

FIG. 8-2

METHANATION: CO + 3H₂ → CH₄ + H₂O
METHANOL
SYNTHESIS: CO + 2H₂ → CH₃OH
H₂/CO (STEAM 70%)
HYDROCARBON FEEDSTOCK GASIFIER FIELD

[0001] The present invention relates to a hydrocarbon feedstock gasifier that gasifies, for example, coal as a hydrocarbon feedstock.

BACKGROUND

[0002] There is a known integrated coal gasification combined cycle (IGCC) that converts coal which is a solid hydrocarbon feedstock to coal gasification gas by a coal gasifier, and uses the coal gasification gas for a gas turbine combined cycle.

[0003] The integrated coal gasification combined cycle has advantages in that abundant reserves of coal resources are used, in that a thermal efficiency is high when compared to a conventional pulverized coal thermal power generation, and the discharge amount of air pollutants such as carbon dioxide is less, and in that coal ash is discharged as a glassy melted slag, and is reduced in volume. Hence, the integrated coal gasification combined cycle is being developed as a main technology of a future coal thermal power generation.

[0004] A two-stage two-chamber entrained flow gasifier proposed as a coal gasifier includes a combustor operated at a high temperature by char (obtained by separating, collecting, and recycling ash+non-reaction carbon in coal gasification gas) and a gasifying agent and coal injected into a first stage (lower stage) within a gasifier, and a reducer that gasifies coal injected into a second stage (upper stage) by energy of high-temperature gas from the combustor (Patent Literature 1 and 2).

CITATION LIST

Patent Literature


SUMMARY

Technical Problem

[0007] Incidentally, a reaction in a coal gasifier appropriately sets an operating condition of the gasifier based on the amount of coal injected into the gasifier, and the amount and ratio of a gasifying agent (air, oxygen, steam, CO₂, and the like).

[0008] As a result, when a gasifier operating condition is set in a target gasifier, a temperature of a gasifier reducer is determined under the same condition, and an exhaust temperature of the gasifier may not be controlled.

[0009] Recently, as an application of coal gasification gas, there is a desire for development of a chemical gasifier that obtains a chemical feedstock such as liquid fuel including methanol (CH₃OH), gaseous fuel including methane (CH₄), and the like. Hence, there is a desire for a gasifier capable of controlling a composition in produced gas (H₂/CO ratio) at a desired value.

[0010] In view of the above issue, an object of the invention is to provide a hydrocarbon feedstock gasifier capable of controlling a composition in produced gas from a gasifier at a desired value.

Solution to Problem

[0011] According to a first aspect of the present invention in order to solve the problems, there is provided a hydrocarbon feedstock gasifier, including: a heat transmission surface provided within a gasification region of a gasifier for generating gasification gas by partially oxidizing a hydrocarbon feedstock; a heat exchanger disposed on a path of a circulation line for a circulation medium circulating within the heat transmission surface and for exchanging the heat of the circulation medium; and a circulation pump for circulating the circulation medium.

[0012] According to a second aspect of the present invention, there is provided the hydrocarbon feedstock gasifier according to the first aspect, wherein the heat transmission surface is a panel type heat transmission surface, and a plurality of heat transmission surfaces is provided along an inner surface of a peripheral wall of the gasifier.

[0013] According to a third aspect of the present invention, there is provided the hydrocarbon feedstock gasifier according to the first aspect, wherein the heat transmission surface is a panel type heat transmission surface, and a plurality of heat transmission surfaces is provided within a space of the gasifier with predetermined intervals.

[0014] According to a fourth aspect of the present invention, there is provided the hydrocarbon feedstock gasifier according to the first aspect, wherein the heat transmission surface is a panel type heat transmission surface, and a plurality of heat transmission surfaces is radially provided within a space of the gasifier with predetermined intervals.

[0015] According to a fifth aspect of the present invention, there is provided the hydrocarbon feedstock gasifier according to any one of claims 1 to 4, wherein steam is further injected into addition to a normal operating condition of gasification.

[0016] According to a sixth aspect of the present invention, there is provided the hydrocarbon feedstock gasifier according to any one of the first to fourth aspects, wherein the gasifier is a two-stage flow gasifier including a combustor provided on a lower side within the gasifier, and a reducer provided on an upper side of the combustor.

[0017] According to a seventh aspect of the present invention, there is provided the hydrocarbon feedstock gasifier according to the sixth aspect, wherein steam is injected into one of or both the reducer and the combustor in addition to a normal operating condition of gasification.

[0018] According to an eighth aspect of the present invention, there is provided the hydrocarbon feedstock gasifier according to any one of the first to seventh aspects, including: a thermometer that measures a temperature of produced gas at an exit of the reducer of the gasifier; and a controller that controls one or both a temperature and a flow rate of the circulation medium supplied to the heat transmission surface so that an exhaust temperature of the produced gas is a predetermined temperature.

[0019] According to a ninth aspect of the present invention, there is provided the hydrocarbon feedstock gasifier according to any one of the first to seventh aspects, including: a gas composition analyzer that measures a gas composition of produced gas at an exit of the reducer of the gasifier; and a controller that controls one of or both a temperature and a flow rate of the circulation medium supplied to the heat transmission surface so that a gas composition of the produced gas is a predetermined composition.
Advantageous Effects of Invention

According to the invention, a heat transmission surface is provided in a reductor of a gasifier, and a fluid temperature/flow rate of a circulation medium supplied to the heat transmission surface is varied, thereby controlling the amount of heat absorption from produced gas in the reductor of the gasifier. As a result, a temperature of produced gas at an exit of the reductor of the gasifier may be adjusted. By controlling a temperature of produced gas, a composition (H_{2}/CO ratio) in the produced gas may be controlled, and thus it is possible to supply gas having a H_{2}/CO ratio near 2 or 3 which is required for a methanol synthesis, and methane (CH_{4})-rich substitute natural gas (SNG fuel). Hence, various types of chemical feedstock may be provided.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic diagram of a hydrocarbon feedstock gasifier according to a first embodiment.

FIG. 2 is a diagram illustrated a relation between a temperature of produced gas and a composition (H_{2}/CO ratio) in the produced gas.

FIG. 3 is a diagram illustrating an example of equipment using the hydrocarbon feedstock gasifier of the embodiment.

FIG. 4-1 is a schematic diagram of a hydrocarbon feedstock gasifier according to a second embodiment.

FIG. 4-2 is a schematic plan view of the gasifier.

FIG. 4-3 is a schematic plan view of the gasifier.

FIG. 5 is a schematic diagram of a hydrocarbon feedstock gasifier according to a third embodiment.

FIG. 6 is a schematic diagram of a hydrocarbon feedstock gasifier according to a fourth embodiment.

FIG. 7 is a schematic diagram of a hydrocarbon feedstock gasifier according to a fifth embodiment.

FIG. 8-1 is a diagram illustrating a relation between a temperature of produced gas and a composition (H_{2}/CO ratio) in the produced gas based on a steam injection (addition of steam 25%).

FIG. 8-2 is a diagram illustrating a relation between a temperature of produced gas and a composition (H_{2}/CO ratio) in the produced gas based on a steam injection (addition of steam 70%).

DESCRIPTION OF EMBODIMENTS

Hereinafter, the invention will be described in detail with reference to the drawings. It should be noted that the invention is not limited to an embodiment, and includes a combination of embodiments when a plurality of embodiments is present. In addition, components in embodiments below include a component easily assumed by those skilled in the art, or the substantially same component.

First Embodiment

A hydrocarbon feedstock gasifier according to an embodiment of the invention will be described with reference to the drawings. FIG. 1 is a schematic diagram of a hydrocarbon feedstock gasifier according to a first embodiment.

As illustrated in FIG. 1, a hydrocarbon feedstock gasifier (hereinafter, referred to as a “gasifier”) 10A according to the embodiment includes a heat transmission surface 15 disposed within a gasification region of a gasifier 13 configured from a pressure vessel for generating produced gas 12 by partially oxidizing a coal 11 which is a hydrocarbon feedstock; a heat exchanger 18 disposed on the path of a circulation line 17 for a circulation medium 16 circulating within the heat transmission surface 15 and for exchanging the heat of the circulation medium 16; and a circulation pump 19 for circulating the circulation medium 16.

Herein, the gasifier 10A according to the embodiment corresponds to a two-stage entrained flow gasifier including a combustor 21 provided on a lower side within the gasifier 13, and a reductor 22 provided on an upper side of the combustor 21.

Into the combustor 21, the coal 11 (pulverized coal) is injected through a fuel supply passage 23A, and a gasifying agent (air) 24 is injected through a gasifying agent supply passage via a burner (not illustrated), and high-temperature combustion gas is generated mainly by a partial combustion of the coal 11. A collected char 28 contained in the produced gas 12 is separated by a cyclone, a filter, and the like, and is supplied into the combustor 21 by a fuel supply passage 23C.

In addition, a melted slag 25 generated and separated in high-temperature gas within the combustor is adhered to a furnace wall or falls on a furnace bottom, and discharged to a lower side from a slag tap 26.

Further, on a lower side of the slag tap 26, coolant 27 that cools down the discharged melted slag 25 is stored at the bottom.

In addition, the coal 11 (pulverized coal) is injected into the reductor 22 through a fuel supply passage 23B via a burner (not illustrated), and is mixed with high-temperature combustion gas generated in the combustor 21 within the reductor 22. As such, a gasification reaction occurs in a high-temperature reduction atmosphere, and the produced gas 12 is obtained.

In the embodiment, a plurality of heat transmission surfaces 15 is provided along a wall surface of the reductor 22 of the gasifier 13.

In the embodiment, the heat transmission surface 15 uses a panel type heat transmission surface along an inner surface of an enclosure pipe of the gasifier, and the heat exchanger 18 and the circulation pump 19 for circulating water which is the circulation medium 16 are disposed on the path of a circulation line 17 on the heat transmission surface 15.

A fluid temperature and a circulation flow rate of the circulation medium 16 supplied to the heat transmission surface 15 are controlled by a control device (not illustrated), thereby controlling the amount of heat absorption from the produced gas 12 in the reductor 22 of the gasifier.

In the embodiment, the panel type heat transmission surface is used. However, the invention is not limited to a panel type as long as heat of the produced gas 12 and the circulation medium 16 may be exchanged.

To control an exhaust temperature of the reductor 22 of the produced gas 12, one of a method of measuring and controlling a temperature of the produced gas 12 at an exit of the reductor 12 using a thermometer (not illustrated), and a method of measuring and controlling a gas composition of the produced gas 12 at the exit of the reductor 22 using a gas composition analyzer that measures the gas composition may be used.

The amount of heat absorption from the produced gas 12 in the reductor 22 is controlled, thereby adjusting a reactant gas temperature of the produced gas 12 at the exit of the reductor 22 of the gasifier 13.
As a result of the temperature control, it is possible to control a composition (H₂/CO ratio) in the produced gas 12.

Herein, a major reaction in gasification gas proceeds as a reaction formula (1) expressed below. Since the reaction is an exothermic reaction (ΔHₘₚ 98~9.8 kcal/mol), the reaction of the formula (1) below proceeds to the right side by controlling a reaction temperature, and decreasing the temperature.

In this instance, heat is generated as the reaction proceeds. Thus, by performing a heat-absorption control of the amount of heat generation of the reaction, it is possible to efficiently control a composition (H₂/CO ratio) in the produced gas 12 such that the composition is H₂-rich.

\[ \text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2 \]  

(1)

FIG. 2 is a diagram illustrating a relation between a temperature of produced gas and a composition (H₂/CO ratio) in the produced gas. As illustrated in FIG. 2, it confirms that a H₂/CO ratio rises from when a reaction temperature decreases below 1,000° C., and approaches a produced gas composition (H₂/CO ratio=2.0) necessary for a methanol synthesis reaction (CO+2H₂→CH₃OH).

A produced gas composition necessary for a methanation reaction (CO+3H₂→CH₄+H₂O) is H₂/CO ratio=3.0.

Therefore, by controlling a gas composition of produced gas that generates produced gas in a gasifier to a hydrogen-rich state necessary for a methanol synthesis and methanation, it is possible to attempt compactification of a CO shift reactor that is separately installed on a slipstream side of the gasifier and includes a CO shift catalyst.

In this way, by controlling a composition (H₂/CO ratio) in the produced gas 12 within the gasifier, it is possible to supply gas having a H₂/CO ratio near 2 and 3 which is required for a methanol synthesis, and methane (CH₄)-rich substitute natural gas (SNG) fuel.

Herein, a chemical reaction formula of the methanol synthesis is expressed by the following formulae (2) and (3).

\[ \text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH} \]  

(2)

\[ \text{CO}_2 + 3\text{H}_2 \rightarrow 2\text{CH}_3\text{OH} \]  

(3)

As such, H₂ necessary for the methanol synthesis is (2CO+3CO₂).

However, in a case where coal is used as a hydrocarbon feedstock, C is great in quantity when compared to H₂. Thus, the synthesis in the reaction of the formula (2) is set to a main reaction, and a CO shift reactor including a shift catalyst and a de-CO₂ device that removes CO₂ generated in the CO shift reaction are installed in front of an entrance of a methanol synthesis unit, thereby adjusting a gas composition to a composition (H₂/CO ratio=2.0) suitable for a methanol synthesis.

In the embodiment, by varying a temperature/flow rate of a fluid supplied to the heat transmission surface 15, the amount of heat absorption of the produced gas 12 in the reductor 22 of the gasifier 13 is controlled.

By controlling the amount of heat absorption from the produced gas 12 in the reductor 22, it is possible to adjust a temperature of produced gas at an exit of the reductor 12 of the gasifier 13, and control a gas composition (H₂/CO ratio) in the produced gas 12 to a desired ratio.

FIG. 3 is a diagram illustrating an example of equipment using hydrocarbon feedstock gasifier of the embodiment.

The produced gas 12 from the gasifier 10A passes through a gas refinement unit 30 provided as necessary, and then passes through a CO shift reactor 31 and a decarbonation device (not illustrated), and is supplied to a methanol synthesis unit 33 as a gas composition (H₂/CO ratio=2.0) necessary for a methanol synthesis, thereby obtaining a liquid fuel (methanol) 34.

In addition, similarly, as a gas composition (H₂/CO ratio=3.0) necessary for a methanation in the CO shift reactor 31, the produced gas 12 is supplied to a methane synthesis unit 35, thereby obtaining a gas fuel (synthetic natural gas (SNG)) 36.

Further, the refined produced gas 12 is supplied to a gas turbine combustion device 41 to drive a gas turbine 42, thereby generating electricity 44 by a generator 43.

The obtained methanol and methane may be used as a fuel, and may be used as a starting material of a chemical feedstock. In addition, the liquid fuel 34 may be used as an auxiliary fuel of the gasifier or a fuel at the time of startup.

In the embodiment, the two-stage entrained flow gasifier including a combustor and a reductor provided on the upper side thereof is given as an example. However, the invention is not limited thereto, and may be applied to a one-stage entrained flow gasifier and the like.

In addition, various carbon feedstocks such as coal (pitch coal, subbituminous coal, and lignite (low grade coal)), biomass, and petroleum coke may be used as the hydrocarbon feedstock.

Second Embodiment

A hydrocarbon feedstock gasifier according to an embodiment of the invention will be described with reference to the drawings. FIG. 4-1 is a schematic diagram of a hydrocarbon feedstock gasifier according to a second embodiment.

As illustrated in FIG. 4-1, a hydrocarbon feedstock gasifier 10B according to the embodiment is not provided along a peripheral wall as in the first embodiment, and a heat transmission surface 15 is suspended by a suspension member (not illustrated).

FIGS. 4-2 and 4-3 are schematic plan views of the gasifier.

In FIG. 4-2, a plurality of suspension type heat transmission surfaces 15 is disposed with predetermined intervals within a gasifier 13.

In FIG. 4-3, a plurality of suspension type heat transmission surfaces 15 is radially disposed within the gasifier 13.

A temperature of a cross-sectional surface of the gasifier may be more uniformized when compared to a case of being provided along the peripheral wall of the first embodiment.

Further, the heat transmission surface may be increased when compared to a case of being provided along the peripheral wall, and thus the amount of heat absorption may be easily controlled. As a result, a reactant gas temperature at an exit of the gasifier may be easily controlled.

A disposition of the plurality of suspension type heat transmission surfaces 15 is not limited to the embodiment.

Third Embodiment

A hydrocarbon feedstock gasifier according to an embodiment of the invention will be described with reference
to the drawings. FIG. 5 is a schematic diagram of a hydrocarbon feedstock gasifier according to a third embodiment.

[0074] As illustrated in FIG. 5, a hydrocarbon feedstock gasifier 10 according to the embodiment further supplies steam 50 into a reductor 22 via a steam supply passage (not illustrated) in the gasifier 10A of the first embodiment.

[0075] When the steam 50 is injected in addition to a normal operating condition (the amount of coal, and a gasifying agent (air, oxygen, steam, CO₂, and the like)) in the gasifier 10A of the first embodiment, it is possible to increase a gas composition H₂/CO ratio in the produced gas 12.

[0076] An independent steam injection to the reductor 22 or a mixed injection to a coal nozzle may be used as an injection of the steam 50. Further, a combination injection of the independent injection and the mixed injection may be used.

[0077] FIGS. 8-1 and 8-2 are diagrams illustrating a relation between a temperature of produced gas and a composition (H₂/CO ratio) in the produced gas based on a different amount of steam injection. Steam accounting for 25% of produced gas is supplied in FIG. 8-1, and steam accounting for 70% of produced gas is injected in FIG. 8-2.

[0078] In this way, it confirms that a composition approaches a produced gas composition (H₂/CO ratio=2.0) necessary for a methanol synthesis, and a produced gas composition (H₂/CO ratio=3.0) necessary for a methanation by increasing the amount of the injected steam 50 even when a rise degree of a H₂/CO ratio is on a high-temperature side.

Fourth Embodiment

[0079] A hydrocarbon feedstock gasifier according to an embodiment of the invention will be described with reference to the drawing. FIG. 6 is a schematic diagram of a hydrocarbon feedstock gasifier.

[0080] As illustrated in FIG. 6, a hydrocarbon feedstock gasifier 10D according to the embodiment further supplies steam 50 into a combustor 21 via a steam supply passage (not illustrated) in the gasifier 10A of the first embodiment.

[0081] Steam is injected into the reductor 22 in the third embodiment, however the steam 50 is injected into the combustor 21 in the embodiment, and thus may be injected into the gasifier 10D as a higher-temperature (high-activation) steam. As a result, a gas composition H₂/CO ratio of the produced gas 12 may be further increased when compared to the third embodiment.

Fifth Embodiment

[0082] A hydrocarbon feedstock gasifier according to an embodiment of the invention will be described with reference to the drawing. FIG. 7 is a schematic diagram of a hydrocarbon feedstock gasifier.

[0083] As illustrated in FIG. 7, a hydrocarbon feedstock gasifier 10E according to the embodiment supplies steam 50 into a combustor 21 and a reductor 22 via a steam supply passage (not illustrated) by combining the third embodiment and the fourth embodiment.

[0084] In the embodiment, an operative range as a gasifier is wide, and a gas composition H₂/CO ratio of produced gas 12 may be increased.

[0085] As described with the embodiments in the foregoing, in the invention, the heat transmission surface 15 is provided in the reductor 22 of the gasifier 13, and a fluid temperature/flow rate of the circulation medium 16 supplied to the heat transmission surface 15 is varied, thereby controlling the amount of heat absorption from the produced gas 12 in the reductor 22 of the gasifier 13. As a result, a temperature of the produced gas 12 at the exit of the reductor 22 of the gasifier 13 may be adjusted.

[0086] In addition, by controlling a temperature of the produced gas 12, a composition (H₂/CO ratio) in the produced gas 12 may be controlled, and thus it is possible to supply gas having a H₂/CO ratio near 2 and 3 which is required for a methanol synthesis, and methane (CH₄)-rich substitute natural gas (SNG fuel) resulting from a methanation reaction. Hence, various types of chemical feedstock may be provided.

REFERENCE SIGNS LIST

[0087] 10A to 10E HYDROCARBON FEEDSTOCK GASIFIER (GASIFIER)
[0088] 11 COAL
[0089] 12 PRODUCED GAS
[0090] 15 HEAT TRANSMISSION SURFACE
[0091] 16 CIRCULATION MEDIUM
[0092] 17 CIRCULATION LINE
[0093] 18 HEAT EXCHANGER
[0094] 19 CIRCULATION PUMP

1. A hydrocarbon feedstock gasifier, comprising:
a gasifier for generating gasification gas by partially oxidizing a hydrocarbon feedstock;
a heat transmission surface provided within a gasification region of the gasifier;
a circulation line for circulating a circulation medium within the heat transmission surface;
a heat exchanger disposed on a path of the circulation line, for exchanging the heat of the circulation medium; and
circulation pump for circulating the circulation medium.
2. The hydrocarbon feedstock gasifier according to claim 1, wherein the heat transmission surface is a panel type heat transmission surface, and a plurality of heat transmission surfaces is provided along an inner surface of a peripheral wall of the gasifier.
3. The hydrocarbon feedstock gasifier according to claim 1, wherein the heat transmission surface is a panel type heat transmission surface, and a plurality of heat transmission surfaces is provided within a space of the gasifier with predetermined intervals.
4. The hydrocarbon feedstock gasifier according to claim 1, wherein the heat transmission surface is a panel type heat transmission surface, and a plurality of heat transmission surfaces is provided within a space of the gasifier with predetermined intervals.
5. The hydrocarbon feedstock gasifier according to claim 1, wherein steam is further injected in addition to a normal operating condition of gasification.
6. The hydrocarbon feedstock gasifier according to claim 1, wherein the gasifier is a two-stage entrained flow gasifier including a combustor provided on a lower side within the gasifier, and a reductor provided on an upper side of the combustor.
7. The hydrocarbon feedstock gasifier according to claim 6, wherein steam is injected into one of or both the reductor and the combustor in addition to a normal operating condition of gasification.
8. The hydrocarbon feedstock gasifier according to claim 1, further comprising:
a thermometer for measuring a temperature of produced gas at an exit of the reductor of the gasifier; and
a controller for controlling one of or both a temperature and a flow rate of the circulation medium supplied to the heat transmission surface so that an exhaust temperature of the produced gas is a predetermined temperature.

9. The hydrocarbon feedstock gasifier according to claim 1, further comprising:

- a gas composition analyzer for measuring a gas composition of produced gas at an exit of the reductor of the gasifier; and
- a controller for controlling one of or both a temperature and a flow rate of the circulation medium supplied to the heat transmission surface so that a gas composition of the produced gas is a predetermined composition.

* * * * *