[Document name] Specification

[Title of the Invention] FLARE GAS COMBUSTION TREATMENT SYSTEM

[Field of the Invention]

[0001]

The present invention relates to a flare gas combustion treatment system that combusts flare gas (also referred to as "hydrocarbon gas" or "hydrocarbon") generated from a refinery, a steel plant, a chemical plant, or a gas storage facility.

[Background Art]

[0002]

A refinery, a steel plant, a chemical plant, and a gas storage facility generate flare gas such as methane. Since the flare gas is combustible, toxic, and has an odor, the flare gas should not be emitted directly into the atmosphere but has to be combusted and discharged in a detoxified state to some extent.

[0003]

In recent years, laws and regulations in the U.S. and other countries have been amended to prohibit the discharge of combustible flare gas in PPM (= parts per million) unit.

[0004]

By the way, one method for combustion treatment of the flare gas that contains a large amount of inert gas such as nitrogen is to use a vapor destruction unit (VDU).

[0005]

A conventional type of the VDU oxidizes and combusts a combustible content in the flare gas under a high-temperature atmosphere where a sufficient amount of combustion air is present, and converts the flare gas to carbon dioxide and water, which are then released into the atmosphere. The VDU has an advantage of being able to combust non-self-combustible flare gas with a small heat generation amount.

[0006]

On the other hand, the conventional type of the VDU has a disadvantage. Hereinafter, a detailed description thereon will be made. In the conventional type of the VDU, in order to create the high-temperature atmosphere, auxiliary fuel is combusted by using a heating burner before the flare gas is introduced into a furnace. As concentration of the combustible content in the flare gas is increased, an amount of the auxiliary fuel for the heating burner is reduced to maintain the furnace at a temperature equal to or lower than a maximum allowable temperature, and then cooling air is forcibly drawn into the furnace to cool inside of the furnace. In the conventional type of the VDU, since the cooling air is forcibly supplied by a blower or the like, a flow rate of the cooling air that can be used (controlled) is limited. For this reason, maximum

concentration of the combustible content in the flare gas that can be treated and a maximum flow rate of the flare gas depend on the flow rate of the cooling air that can be supplied forcibly by the blower or the like.

[0007]

Another method for the combustion treatment of the self-combustible flare gas is an enclosed ground flare (EGF).

[0008]

For the flare gas whose flow rate fluctuates from 0 to 100%, the number of flare burners that combust the flare gas is adjusted in steps according to the flow rate. Then, the EGF combusts the flare gas. In detail, a flare gas path to each of the flare burners is provided, and a shut-off valve is provided in each of the paths. Depending on a supplied amount of the flare gas, the number of the paths to be led is adjusted by using the shut-off valves, and the number of the flare burners to be operated is thereby adjusted in steps. This technique is known as "staging control for the EGF".

[Citation List]

[Patent Document]

[0009]

[Patent Document 1] JP-U-58-128352

[0010]

For example, the following configuration is disclosed as the related art in Patent Document 1. In a flare gas combustion system (grand flare), several stages of combustion zones (≈ stages) are provided in a flare gas combustion treatment device to handle the flare gas flow rate from the plant, and, in order to make combustion smoother, a staging switcher (supply/shut-off device) is provided to one or plural secondary paths other than a primary path for introducing the flare gas. In the case where a flare gas pressure in the primary path becomes high, the staging switcher (supply/shut-off device) opens the secondary path by an electric signal using an instrument air pressure, allowing the flare gas to flow into the secondary path as well.

[0011]

In the case where the flare gas has the small heat generation amount and thus the stable combustion cannot be expected, the auxiliary fuel is injected into the flare gas in advance to increase the heat generation amount for combustion. In addition, in the case where the concentration of the combustible content in the flare gas is low, a larger amount of the auxiliary fuel than that for the VDU is required to ensure stable self-combustion.

[0012]

In addition, the flow rate of the flare gas fluctuates instantaneously. Thus, when adjusting an injection amount of the auxiliary fuel according to the concentration of the combustible

content in the flare gas, two processes of "measuring the flow rate of the flare gas and the concentration of the combustible content and calculating an optimum injection amount of the auxiliary fuel on the basis of the measurement results" have to be performed instantaneously. However, it is not realistic to perform these processes instantaneously. As a result, the injection amount of the auxiliary fuel is calculated and injected on the basis of a minimum standard for the concentration of the combustible content, which increases cost of the auxiliary fuel to be equal to or higher than required cost.

[Disclosure of the Invention]

[Problem to be Solved by the Invention]

[0013]

From what have been described so far, there is a limitation on application of the conventional VDU based on an amount of the cooling air by the blower or the like, and there is a cost disadvantage for the EGF based on the injection amount of the auxiliary fuel. For this reason, no technique has existed that can combust the non-self-combustible flare gas with the small heat generation amount and that can handle the instantaneously fluctuating flow rate of the flare gas while minimizing the cost.

[0014]

In view of the above, in order to solve the above problems, the present invention has a purpose of providing a flare gas combustion treatment system capable of combusting a wide range of flare gas, including non-self-combustible flare gas with a small heat generation amount and self-combustible flare gas, and capable of handling an instantaneously fluctuating flow rate of the flare gas while minimizing cost of auxiliary fuel.

[Means for Solving the Problem]

[0015]

In order to achieve the above purpose, the invention according to claim 1 is

a flare gas combustion treatment system for combustion treatment of flare gas,

the system includes: a VDU and an EGF; and an information processor that controls the entire system, in which

one end of a flare gas line, through which the flare gas is supplied, is connected to each of the VDU and the EGF,

a supply/shut-off device that allows/shuts off a flow of the flare gas and controls a flow rate of the flare gas is provided in the middle of a flare gas line toward the VDU and in the middle of a flare gas line toward the EGF,

when the flare gas is subjected to combustion treatment by the VDU, the information processor operates the supply/shut-off device for the EGF to close the flare gas line toward the EGF, and

when the flare gas is subjected to the combustion treatment by the EGF, the information processor operates the supply/shut-off device for the VDU to close the flare gas line toward the VDU or control the flow rate.

[0016]

The invention according to claim 2 is

the flare gas combustion treatment system according to claim 1 in which the flare gas that has low concentration of a combustible content in the flare gas and is not self-combustible is subjected to the combustion treatment by the VDU.

[0017]

The invention according to claim 3 is

the flare gas combustion treatment system according to claim 1 or 2 in which

an air intake damper that draws air from outside is provided to the VDU,

the information processor controls an amount of auxiliary fuel when a temperature inside the VDU is increased to be equal to or higher than a preset temperature, and

in the case where the temperature inside the VDU is equal to or higher than the preset temperature even after the amount of the auxiliary fuel is controlled, the air intake damper is opened to draw the air into the VDU from the outside by natural suction.

[0018]

The invention according to claim 4 is

the flare gas combustion treatment system according to any one of claims 1 to 3 in which, when the temperature inside the VDU is equal to or higher than the preset temperature, the information processor operates the supply/shut-off device for the VDU to close the flare gas line toward the VDU or control the flow rate, and operates the supply/shut-off device for the EGF to open the flare gas line toward the EGF.

[0019]

The invention according to claim 5 is

the flare gas combustion treatment system according to any one of claims 1 to 4, in which, when a flare gas pressure becomes equal to or lower than a preset value of the flare gas pressure in association with a reduction in the flow rate of the flare gas, the information processor operates the supply/shut-off device for the EGF to close the flare gas line toward the EGF, and operates the supply/shut-off device for the VDU to open the flare gas line toward the VDU or control the flow rate.

[0020]

The invention according to claim 6 is

the flare gas combustion treatment system according to any one of claims 1 to 5, in which

another end of the flare gas line is connected to a combustible gas reservoir for storing the flare gas and provided with a safety valve that is actuated when being over-pressurized,

a distance from the one end to the other end of the flare gas line has such a length that it takes at least several seconds for the flare gas that has flowed out from the other end to reach the one end,

a safety valve detector that detects actuation of the safety valve is provided in the middle of the flare gas line near the combustible gas reservoir,

when a pressure inside the combustible gas reservoir becomes over-pressurized, and the safety valve is thereby actuated, the safety valve detector detects the actuation and outputs a signal indicating the actuation to the information processor, and

when receiving the signal, the information processor operates the supply/shut-off device for the VDU to close the flare gas line toward the VDU or control the flow rate, and operates the supply/shut-off device for the EGF to open the flare gas line toward the EGF.

[Effect of the Invention]

[0021]

In the present invention, due to combination of the VDU and the EGF, the flare gas is subjected to the combustion treatment by the VDU when the concentration of the combustible content in the flare gas is low, and the flare gas is subjected to the combustion treatment by the EGF when the concentration of the combustible content in the flare gas is high. Thus, the flare gas can be subjected to the combustion treatment economically and efficiently regardless of the concentration of the combustible content. In addition, switching between the VDU and the EGF is instantaneously performed on the basis of a command from the information processor. Thus, in the case where the flare gas that contains a large amount of the combustible content is suddenly supplied in the event of abnormality or the like, the combustion treatment can be performed safely by switching to the EGF. On the other hand, in the case where the concentration of the combustible content in the flare gas is low and the flare gas is not self-combustible, or the like, the combustion treatment is performed by switching to the VDU. In this way, the combustion treatment can always be performed with a bare minimum amount of the auxiliary fuel for convenience.

[Brief Description of Drawings]

[0022]

FIG. 1 is a schematic configuration view of a flare gas combustion treatment system according to a first embodiment of the present invention.

FIG. 2 is an explanatory view illustrating a flow of fuel and a flow of flare gas when a VDU is used in the flare gas combustion treatment system according to the first embodiment of the present invention.

FIG. 3 is an explanatory view illustrating the flow of the fuel and the flow of the flare gas in a second stage state when an EGF is used in the flare gas combustion treatment system according to the first embodiment of the present invention.

FIG. 4 is an explanatory view illustrating the flow of the fuel and the flow of the flare gas in a third stage state when the EGF is used in the flare gas combustion treatment system according to the first embodiment of the present invention.

FIG. 5 is a flowchart illustrating a processing procedure at the time when an amount of the flare gas is increased in the flare gas combustion treatment system according to the first embodiment of the present invention.

FIG. 6 is a flowchart illustrating a processing procedure at the time when the amount of the flare gas is reduced in the flare gas combustion treatment system according to the first embodiment of the present invention.

[Description of Embodiments]

[0023]

(First Embodiment)

A detailed description will hereinafter be made on a first embodiment according to the present invention with reference to the accompanying drawings. It should be noted that components described in this embodiment are merely illustrative and are not intended to limit the scope of the present invention thereto.

[0024]

<Configuration of Flare Gas Combustion Treatment System>

FIG. 1 is a schematic configuration view of a flare gas combustion treatment system according to this first embodiment. The flare gas combustion treatment system has a VDU 1 and an EGF 3. The VDU 1 has a cylindrical body 20 and has a columnar shape. The EGF 3 has a cylindrical body 30 and has a columnar shape. In this first embodiment, the columnar configurations of the VDU 1 and the EGF 3 are illustrated. However, these are merely illustrative, and at least one of the VDU 1 and the EGF 3 may have a prismatic shape. In addition, shapes of the VDU 1 and the EGF 3 are not limited. The VDU 1 and the EGF 3 each play a role of a furnace (≈ a combustion chamber) to combust supplied flare gas. Accordingly, hereinafter, the "VDU 1" will refer to a furnace that acts as a VDU for a combustion treatment method, and the "EGF 3" will refer to a furnace that acts as an EGF for the combustion treatment method. The VDU 1 and the EGF 3 are also referred to as flare stacks.

[0025]

<Configuration of VDU 1>

The VDU 1 is provided with plural air intake holes (not illustrated) in a lower portion, and each air intake damper 21 covers the respective hole. In this first embodiment, the configuration

is described that is provided with the plural air intake holes and is also provided with the plural air intake dampers 21 for covering those holes. However, the present invention is not limited to such a configuration. A configuration that a single outside air intake hole is provided and the air intake damper 21 covers such a hole may be adopted.

[0026]

The VDU 1 is also provided with: an auxiliary fuel burner 23 to maintain inside of the furnace under a high-temperature atmosphere; and a flare burner A-1 and a pilot burner 14, each of which combusts the flare gas supplied into the furnace. Furthermore, a temperature detector 50, such as a thermocouple, that detects a temperature inside the VDU 1 is provided to an upper portion of the VDU 1.

[0027]

<Configuration of EGF 3>

The EGF 3 has a structure of supporting the cylindrical body 30 with plural column bases 32. Accordingly, outside air (air) flows into the EGF 3 from an air intake zone 31 on a lower side of the cylindrical body 30 through a space between the column bases 32. In this first embodiment, the structure of supporting the cylindrical body 30 with the column bases 32 is described. However, the structure of supporting the cylindrical body 30 is not limited to such a structure. A configuration only needs to be that the air intake zone 31 is provided to the cylindrical body 30 and the outside air (air) can flow into the EGF 3 from the air intake zone 31. For this reason, for example, a configuration may be adopted that the cylindrical body 30 is integrally molded with bases supporting the cylindrical body 30 and that plural holes are provided as the air intake zone 31 to the cylindrical body 30.

[0028]

The EGF 3 is also provided with flare burners B-1, C-1, D-1, …, N-1, and pilot burners 15 that combust the flare gas supplied into the furnace. In order to instantaneously ignite the supplied flare gas, the pilot burner 14 in the VDU 1 and the pilot burner 15 in the EGF 3 are constantly supplied with the fuel and constantly combust the fuel.

[0029]

One end of a fuel line 10 is connected to the VDU 1 to supply the fuel. In detail, two fuel lines of a fuel line 12 and a VDU auxiliary fuel burner fuel line 13 are connected to the VDU 1. The fuel line 12 is branched from a fuel line 11, through which the fuel is supplied to the pilot burner 15 in the EGF 3, and which supplies the fuel to the pilot burner 14 in the VDU 1. The VDU auxiliary fuel burner fuel line 13 is used to supply auxiliary fuel to the auxiliary fuel burner 23. An auxiliary fuel flow rate regulator 22 capable of regulating an amount of the auxiliary fuel that flows through the VDU auxiliary fuel burner fuel line 13 is provided in the middle of the fuel

line 13.

[0030]

The one end of the fuel line 10 is also connected to the EGF 3 to supply the fuel. In detail, the branched fuel line 11 is connected to the EGF 3 in order to supply the fuel to each of the EGF pilot burners 15 that are installed in a manner to correspond to the flare burners such as the flare burners B-1, C-1, D-1, …, N-1, respectively.

[0031]

In addition, one end of a flare gas line 40 is connected to each of the VDU 1 and the EGF 3 to supply the flare gas thereto. In detail, the flare gas line 40 is branched in the middle into a VDU-directed flare gas line 42 toward the VDU 1 and plural EGF-directed flare gas lines 43, 44, 45, …, 4X toward the EGF 3, and is connected to the VDU 1 and the EGF 3. A VDU/EGF flare gas switching device A capable of allowing/shutting off a flow of the flare gas toward the VDU 1 and capable of regulating (controlling) a flow rate of such flare gas is provided in the middle of the flare gas line 42 toward the VDU 1. The VDU/EGF flare gas switching device A is a supply/shut-off valve, for example.

[0032]

The other end of the flare gas line 40 is connected to a combustible gas reservoir 80. This combustible gas reservoir 80 stores the flare gas to be subjected to combustion treatment, and causes the stored flare gas to flow out when the combustion treatment is performed. In addition, in order to ensure safety, the combustible gas reservoir 80 is provided at a position sufficiently away from flare gas treatment facilities such as the VDU 1 and the EGF 3. Thus, a distance between the one end and the other end of the flare gas line 40 is equal to or longer than 100 m, for example. For this reason, it takes several seconds (≈ two or three seconds) or longer for the flare gas that has flowed out of the combustible gas reservoir 80 to reach the VDU 1 or the EGF 3.

[0033]

As described above, the plural flare burners B-1 to N-1 are provided in the EGF 3. Accordingly, in order to supply the flare gas to each of the flare burners, the flare gas line 40 is branched into the EGF-directed flare gas lines 43, 44, 45, …, 4X and lines, the number of which matches the number of flare burner lines provided in the EGF 3. EGF flare gas supply/shut-off devices B, C, D, …, N capable of allowing/shutting off a flow of the flare gas toward the EGF 3 and capable of regulating (controlling) a flow rate of such flare gas are provided in the middle of the respective branched flare gas lines. Each of the EGF flare gas supply/shut-off devices B to N only needs to have a configuration capable of allowing/shutting off the flow of the flare gas toward the EGF 3 and capable of regulating (controlling) the flow rate of such flare gas, and is a supply/shut-off valve, for example.

[0034]

The flare gas line 40 before being branched is provided with a flare gas pressure detector 60 that detects a pressure of the flowing flare gas. In the case where a B to N flare gas supply/switching operation arithmetic device 61 recognizes that a pressure value of the flare gas detected by the flare gas pressure detector 60 exceeds a set value, the EGF flare gas supply/shut-off device B and the like are operated to open the flare gas line 43 and the like, and the flare gas is thereby supplied to the EGF 3. At the same time, when recognizing the operation of the EGF flare gas supply/shut-off device B and the like by the B to N flare gas supply/switching operation arithmetic device 61, a comprehensive information processor (not illustrated and described below) operates the VDU/EGF flare gas switching device A through a VDU/EGF flare gas switching operation arithmetic device 71, so as to shut off the flare gas line 42 toward the VDU 1.
[0035]

A safety valve detector 70 is provided in the middle of the flare gas line 40 before being branched. When a pressure in the combustible gas reservoir 80 becomes over-pressurized, and a safety valve is actuated (opened), the safety valve detector 70 detects the actuation and outputs a signal indicating the actuation to the VDU/EGF flare gas switching operation arithmetic device 71. When receiving the signal, the VDU/EGF flare gas switching operation arithmetic device 71 operates the VDU/EGF flare gas switching device A to close the flare gas line 42 toward the VDU 1 and to thereby shut off the flow of the flare gas. At the same time, when recognizing the operation of the VDU/EGF flare gas switching device A by the VDU/EGF flare gas switching operation arithmetic device 71, the comprehensive information processor operates the EGF flare gas supply/shut-off device B and the like through the B to N flare gas supply/switching operation arithmetic device 61, so as to open the flare gas line 43 and the like, and the flare gas is thereby supplied to the EGF 3.
[0036]

A position on the flare gas line 40 where the safety valve detector 70 is provided is a position before the flare gas line 40 is branched and near the combustible gas reservoir 80 (usually sufficiently away from the flare gas treatment facilities to ensure the safety). Accordingly, when the safety valve is actuated, at a time point at which the flare gas that has flowed out of the combustible gas reservoir 80 reaches a flare gas line header 41 (or before such flare gas reaches the flare gas line header 41), the VDU/EGF flare gas switching device A is operated via the VDU/EGF flare gas switching operation arithmetic device 71. In this way, the flare gas line 42 toward the VDU 1 can be closed. At the same time, the EGF flare gas supply/shut-off device B and the like are operated via the comprehensive information processor and the B to N flare gas supply/switching operation arithmetic device 61 to open the flare gas line 43 and the like, and the flare gas can thereby be supplied to the EGF 3. From what have been described so far, in case of emergency such as a case where the safety valve detector 70 detects

that the safety valve is opened, a supply destination of the flare gas is switched before the flare gas reaches the VDU 1. In this way, the flare gas can flow into the EGF 3 for convenience.

[0037]

This flare gas combustion treatment system is entirely controlled by using an information processor such as a server.

Hereinafter, a detailed description thereon will be made.

[0038]

The VDU 1 is provided with, as the information processors, an auxiliary fuel regulation arithmetic device 51 and an air intake damper opening amount regulator 52. The auxiliary fuel regulation arithmetic device 51, the air intake damper opening amount regulator 52, and the temperature detector 50 are connected in a mutually communicable manner. In addition, the auxiliary fuel regulation arithmetic device 51 is connected to the auxiliary fuel flow rate regulator 22 in the mutually communicable manner. Furthermore, the air intake damper opening amount regulator 52 is connected to each of the air intake dampers 21 in the mutually communicable manner.

[0039]

The auxiliary fuel regulation arithmetic device 51 causes the temperature detector 50 to detect the temperature inside the VDU 1 and operates the auxiliary fuel flow rate regulator 22 on the basis of the temperature, so as to regulate the amount of the auxiliary fuel to be supplied to the auxiliary fuel burner 23. Meanwhile, the air intake damper opening amount regulator 52 causes the temperature detector 50 to detect the temperature inside the VDU 1 and regulates an opening degree of each of the air intake dampers 21 on the basis of the temperature.

[0040]

The EGF 3 is provided with, as the information processors, the B to N flare gas supply/switching operation arithmetic device 61 and the VDU/EGF flare gas switching operation arithmetic device 71. In addition, the B to N flare gas supply/switching operation arithmetic device 61 is connected to the EGF flare gas supply/shut-off devices B, C, D, …, N in the mutually communicable manner. Furthermore, the VDU/EGF flare gas switching operation arithmetic device 71 is connected to the VDU/EGF flare gas switching device A in the mutually communicable manner.

[0041]

The B to N flare gas supply/switching operation arithmetic device 61 causes the flare gas pressure detector 60 to detect the pressure of the flare gas that flows through the flare gas line 40 before flowing into the flare gas line header 41 (a portion of the flare gas line 40 before being branched), and operates the EGF flare gas supply/shut-off devices B, C, D, …, N on the basis of the pressure, so as to open or shut off the flare gas line 43 and the like and regulate (control) the

flow rate of the flare gas flowing through the flare gas line 43 and the like. Meanwhile, in response to a command from the comprehensive information processor, the VDU/EGF flare gas switching operation arithmetic device 71 operates the VDU/EGF flare gas switching device A to open/shut off the flare gas line 42 and control the flow rate of the flare gas flowing through the flare gas line 42.

[0042]

Each of the auxiliary fuel regulation arithmetic device 51, the air intake damper opening amount regulator 52, the B to N flare gas supply/switching operation arithmetic device 61, and the VDU/EGF flare gas switching operation arithmetic device 71 is connected to the comprehensive information processor (not illustrated) in the mutually communicable manner. The comprehensive information processor is higher than the auxiliary fuel regulation arithmetic device 51, the air intake damper opening amount regulator 52, the B to N flare gas supply/switching operation arithmetic device 61, and the VDU/EGF flare gas switching operation arithmetic device 71, and plays a role of controlling the flare gas combustion treatment system according to this first embodiment comprehensively. Accordingly, the comprehensive information processor receives information and commands from the auxiliary fuel regulation arithmetic device 51, the air intake damper opening amount regulator 52, the B to N flare gas supply/switching operation arithmetic device 61, and the VDU/EGF flare gas switching operation arithmetic device 71, and outputs information and the commands to the auxiliary fuel regulation arithmetic device 51, the air intake damper opening amount regulator 52, the B to N flare gas supply/switching operation arithmetic device 61, and the VDU/EGF flare gas switching operation arithmetic device 71.

[0043]

<Processing Procedure of Flare Gas Combustion Treatment System>

Next, a description will be made on a processing procedure of the flare gas combustion treatment system according to this first embodiment with reference to FIG. 2 to FIG. 6. First, a description will be made on a processing procedure when an amount of the flare gas is increased. As illustrated in FIG. 2 and FIG. 5, the auxiliary fuel regulation arithmetic device 51 operates the auxiliary fuel flow rate regulator 22, supplies the auxiliary fuel to the auxiliary fuel burner 23, which is provided to the VDU 1, through the fuel lines 10, 13, and causes the auxiliary fuel burner 23 to ignite and combusts the auxiliary fuel. In addition, the auxiliary fuel regulation arithmetic device 51 causes the temperature detector 50 to continuously detect the temperature inside the VDU 1 and supplies the auxiliary fuel such that the temperature inside the VDU 1 is increased from an ambient temperature to a set temperature 1 (step S501). Here, the "set temperature 1" means a temperature at which a combustible content in the flare gas is ignited (for example, about 400 to 600 °C). As illustrated in FIG. 2, when recognizing that the temperature

inside the VDU 1 has reached the set temperature 1 by the information received from the auxiliary fuel regulation arithmetic device 51, the comprehensive information processor causes the VDU/EGF flare gas switching operation arithmetic device 71 to supply the flare gas into the VDU 1 via the flare gas lines 40, 41, 42 and causes the pilot burner 14 for the VDU 1 to ignite and combust the flare gas that has flowed into the flare burner A-1. This is a first stage.

[0044]

While continuing supply and combustion of the flare gas, the auxiliary fuel regulation arithmetic device 51 operates the auxiliary fuel flow rate regulator 22 to regulate the amount of the fuel supplied to the flare burner A-1, and causes the temperature detector 50 to continuously detect the temperature inside the VDU 1, so as to maintain the temperature inside the VDU 1 to be equal to or higher than the set temperature 1 (step S502). For example, the temperature inside the VDU 1 is maintained at 600 to 800 °C. Such temperature is a "set temperature 2". This "set temperature 2" is a temperature at which the flare gas is decomposed and combusted (= a temperature at which an optimum combustion condition can be met, the optimum combustion condition being that an amount of a non-combusted component is minimized and the cylindrical body 20 as the combustion cylinder is not deteriorated).

[0045]

When recognizing that concentration of the combustible content in the supplied flare gas (= an amount of combustible gas in the flare gas) is increased and that the temperature inside the VDU 1 is increased from the set temperature 2 through the temperature detector 50, the auxiliary fuel regulation arithmetic device 51 operates the auxiliary fuel flow rate regulator 22 to reduce the amount of the auxiliary fuel supplied to the auxiliary fuel burner 23 and reduce the temperature inside the VDU 1 to the set temperature 2 (step S503).

[0046]

In a state where the amount of the auxiliary fuel is reduced to a minimum amount that can be combusted by the auxiliary fuel burner 23 (= a minimum flow rate), when recognizing that the temperature inside the VDU 1 is increased from the set temperature 2, the air intake damper opening amount regulator 52 regulates the opening amount of each of the air intake dampers 21, draws the air into the VDU 1 from the outside, and reduces the temperature inside the VDU 1 to the set temperature 2 (step S504). As a characteristic of the burner, the percentage of the minimum flow rate with respect to a maximum flow rate (a maximum combustion amount) is generally determined for each of the burners.

[0047]

When the concentration of the combustible content in the supplied fuel gas (= the amount of the combustible gas in the flare gas) is increased, and the comprehensive information processor recognized that the temperature inside the VDU 1 has been increased to a set

temperature 3 (for example, 1000 °C) by the information received from the auxiliary fuel regulation arithmetic device 51, the comprehensive information processor causes the VDU/EGF flare gas switching operation arithmetic device 71 to operate the VDU/EGF flare gas switching device A to completely close the flare gas line 42 and switch the flow of the flare gas to the flow toward the EGF 3 (step S505). In addition, when recognizing from the temperature detector 50 that the temperature inside the VDU 1 has been increased to the set temperature 3, the auxiliary fuel regulation arithmetic device 51 regulates the amount of the auxiliary fuel, which is supplied to the auxiliary fuel burner 23 through the VDU auxiliary fuel burner fuel line 13, according to the temperature increase of the VDU 1. At the set temperature 3, the flow rate of the auxiliary fuel is regulated to the minimum flow rate, and the temperature inside the VDU 1 is reduced to the set temperature 1. The "set temperature 3" is the highest temperature at which the cylinder body 20 as the combustion cylinder is not deteriorated over long-term operation.

[0048]

As described above, the flare gas combustion treatment system according to this first embodiment is configured that the VDU 1 performs the combustion treatment of the non-self-combustible flare gas, in which the concentration of the combustible content is low, and the auxiliary fuel is used to create the high-temperature atmosphere in the VDU 1. In this way, the fluctuation in the concentration of the combustible content in the flare gas can be comprehended as the temperature change in the VDU 1. Thus, the amount of the supplied auxiliary fuel can be reduced by regarding the temperature increase inside the VDU 1 as the increase in the concentration of the combustible content in the flare gas. As a result, it is possible to constantly suppress the amount of the supplied auxiliary fuel to a bare minimum amount while preventing an excessive increase in the temperature inside the VDU 1.

[0049]

It is also configured that, when the concentration of the combustible content in the supplied flare gas (= the amount of the combustible gas in the flare gas) is increased and the temperature inside the VDU 1 is increased to the set temperature 2, which is set in advance, in the state where the amount of the auxiliary fuel is reduced to the minimum amount, with which the auxiliary fuel burner 23 can combust the auxiliary fuel, (= the minimum flow rate), the air intake dampers 21 are opened to draw the air into the VDU 1 from the outside. Just as described, the configuration of using natural draft (= drawing of the air from the outside is also referred to as "natural suction") to cool the inside of the furnace is also a factor of being able to suppress the amount of the auxiliary fuel to the bare minimum amount.

[0050]

The primary role of the VDU 1 in the flare gas combustion treatment system according to this first embodiment is the combustion treatment of the flare gas having 100% of the

noncombustible content and the concentration of the combustible content that cannot be self-combustible. For this reason, the VDU 1 is configured to create the high-temperature atmosphere in the furnace by using the auxiliary fuel and be able to comprehend the fluctuation in the concentration of the combustible content in the flare gas as the temperature change in the furnace, and the inside of the furnace is cooled by the natural draft in the system. Thus, size of the VDU 1 only needs to be a volume that allows the VDU 1 to play the above-described primary role, and does not have to correspond to the maximum flare gas flow rate. In the case of the flare gas combustion treatment system that is not provided with the EGF and is only provided with the VDU, the VDU requires the size of VDU + EGF in order to handle "the maximum flow rate × a maximum heat generation amount of the flare gas".

[0051]

Herein, the description returns to the processing procedure of the flare gas combustion treatment system. When recognizing that the temperature inside the VDU 1 has been increased to the set temperature 3 (for example, 1000 °C) by the information received from the auxiliary fuel regulation arithmetic device 51, the comprehensive information processor causes the VDU/EGF flare gas switching operation arithmetic device 71 to operate the VDU/EGF flare gas switching device A to completely close the flare gas line 42 (step S505). At the same time, as illustrated in FIG. 3, the comprehensive information processor causes the B to N flare gas supply/switching operation arithmetic device 61 to operate the EGF flare gas supply/shut-off device B, which is provided in the middle of the flare gas line 43 toward the EGF 3, to open the flare gas line 43 (step S506), and causes the flare gas to flow into the flare burner B-1 through the flare gas line 43 for the combustion treatment. This is a second stage. Just as described, a switching time from the VDU 1 to the EGF 3 is reduced by simultaneously executing step S505 and step S506.

[0052]

Next, when recognizing, from the flare gas pressure detector 60, the increase in the combustible content in the flare gas and an increase in the flare gas pressure that is associated with the increase in the flow rate of the flare gas (=becoming equal to or higher than a preset value of the flare gas pressure), as illustrated in FIG. 4, the B to N flare gas supply/switching operation arithmetic device 61 operates the EGF flare gas supply/shut-off device C to open the flare gas line 44 in addition to the flare gas line 43 (step S507), and causes the flare gas to flow into the flare burner C-1 through the flare gas line 44 for the combustion treatment. This is a third stage.

[0053]

Similarly, when recognizing, from the flare gas pressure detector 60, the further increase in the combustible content in the flare gas and the further increase in the flare gas pressure that is

associated with the further increase in the flow rate of the flare gas, the B to N flare gas supply/switching operation arithmetic device 61 sequentially operates the EGF flare gas supply/shut-off device D to open the flare gas line 45 in addition to the flare gas lines 43, 44 (a fourth stage, step S508), and also operates the EGF flare gas supply/shut-off device N to open the flare gas line 4X (an Nth stage, step S509).

[0054]

Next, a description will be made on a processing procedure when the amount of the flare gas is reduced. When recognizing, from the flare gas pressure detector 60, a reduction in the flare gas pressure (= becoming equal to or lower than the preset value of the flare gas pressure) that is associated with a reduction in the flow rate of the flare gas, as illustrated in FIG. 6, the B to N flare gas supply/switching operation arithmetic device 61 sequentially lowers the treatment stage (the stage number) from the EGF flare gas supply/shut-off device N (the Nth stage). That is, sequentially, the EGF flare gas supply/shut-off device N is operated to close the flare gas line 4X and shut off the flow of the flare gas (the Nth stage, step S601), the EGF flare gas supply/shut-off device D is operated to close the flare gas line 45 and shut off the flow of the flare gas (the fourth stage, step S602), and the EGF flare gas supply/shut-off device C is operated to close the flare gas line 44 and shut off the flow of the flare gas (the third stage, step S603).

[0055]

Next, when recognizing, from the flare gas pressure detector 60, the further reduction in the flare gas pressure (=becoming equal to or lower than the preset value of the flare gas pressure) that is associated with the further reduction in the flow rate of the flare gas, the B to N flare gas supply/switching operation arithmetic device 61 operates the EGF flare gas supply/shut-off device B to close the flare gas line 43 and shut off the flow of the flare gas (the second stage, step S604), and stops the supply of the flare gas to the EGF 3.

[0056]

At the same time, when recognizing that the supply of the flare gas to the EGF 3 is stopped by the information received from the B to N flare gas supply/switching operation arithmetic device 61, the comprehensive information processor causes the VDU/EGF flare gas switching operation arithmetic device 71 to operate the VDU/EGF flare gas switching device A to open the flare gas line 42 (step S605), and the flare gas is thereby supplied to the VDU 1. Just as described, a switching time from the EGF 3 to the VDU 1 is reduced by simultaneously executing step S604 and step S605.

[0057]

In the VDU 1, the specified amount of the auxiliary fuel is constantly supplied to the auxiliary fuel burner 23, and the temperature inside the VDU 1 is maintained at the set

temperature 1. Thus, when the flare gas is supplied to the flare burner A-1, the flare gas is subjected to the combustion treatment (step S606).

[0058]

As described above, in the flare gas combustion treatment system according to this first embodiment, due to the combination of the VDU 1 and the EGF 3, the flare gas is subjected to the combustion treatment by the VDU 1 when the concentration of the combustible content in the flare gas is low, and the flare gas is subjected to the combustion treatment by the EGF 3 when the concentration of the combustible content in the flare gas is high. Thus, the flare gas can be subjected to the combustion treatment economically and efficiently regardless of the concentration of the combustible content. In addition, switching between the VDU 1 and the EGF 3 is instantaneously performed on the basis of the command from the information processor such as the VDU/EGF flare gas switching operation arithmetic device 71. In detail, a time required for opening/shutting off of the flare gas line by each of the VDU/EGF flare gas switching device A, the EGF flare gas supply/shut-off device B, and the like is several seconds, and the VDU/EGF flare gas switching operation arithmetic device 71 and the like start the operation of the devices at the same time. Thus, in the case where the flare gas that contains the large amount of the combustible content is suddenly supplied in the event of abnormality or the like, the combustion treatment can be performed safely by switching to the EGF 3 instantaneously. On the other hand, in the case where the concentration of the combustible content in the flare gas is low and the flare gas is not self-combustible, or the like, the combustion treatment is performed by switching to the VDU 1. In this way, the combustion treatment can always be performed with the bare minimum amount of the auxiliary fuel for convenience. In general, there is a case where the cost of the auxiliary fuel becomes several hundred million yen per year when the flare gas is subjected to the combustion treatment only by the EGF 3. However, by combining the VDU 1 and the EGF 3, the cost of the auxiliary fuel can be reduced to 10% or lower, that is, to several million yen per year.

[0059]

In the flare gas combustion treatment system according to this first embodiment, the configuration has been described that is provided with the flare gas lines 43, 44, 45, …, 4X and the plural flare gas lines toward the EGF 3. However, the number of the flare gas lines toward the EGF 3 only needs to match the treatment stages (the number of the stages) of the EGF 3. Similarly, the number of the flare burners provided in the EGF 3 and the number of the EGF flare gas supply/shut-off devices only need to match the treatment stages (the number of the stages) of the EGF 3.

[0060]

In the flare gas combustion treatment system according to this first embodiment, the configuration has been described that the five information processors, the comprehensive information processor, the auxiliary fuel regulation arithmetic device 51, the air intake damper opening amount regulator 52, the B to N flare gas supply/switching operation arithmetic device 61, and the VDU/EGF flare gas switching operation arithmetic device 71, are provided independently. However, the present invention is not limited to this configuration. For example, such a configuration may be adopted that a single information processor having the functions of the auxiliary fuel regulation arithmetic device 51 and the air intake damper opening amount regulator 52 is used. Alternatively, such a configuration may be adopted that a single information processor having the functions of the B to N flare gas supply/switching operation arithmetic device 61 and the VDU/EGF flare gas switching operation arithmetic device 71 is used. Further alternatively, such a configuration may be adopted that a single information processor having the functions of the comprehensive information processor, the auxiliary fuel regulation arithmetic device 51, the air intake damper opening amount regulator 52, the B to N flare gas supply/switching operation arithmetic device 61, and the VDU/EGF flare gas switching operation arithmetic device 71 is used.

[Description of Reference Numerals and Symbols]

[0061]

A: VDU/EGF flare gas switching device
A-1: flare burner
B: EGF flare gas supply/shut-off device
C: EGF flare gas supply/shut-off device
D: EGF flare gas supply/shut-off device
N: EGF flare gas supply/shut-off device
1: VDU
10: fuel line
11: EGF pilot burner fuel line
12: VDU pilot burner fuel line
13: VDU auxiliary fuel burner fuel line
14: pilot burner
15: pilot burner
20: VDU cylindrical body
21: air intake damper
22: auxiliary fuel flow rate regulator
23: auxiliary fuel burner
3: EGF

30: EGF cylindrical body
31: EGF air intake zone
32: column base
40: flare gas line
41: flare gas line header
42: VDU-directed flare gas line
43: EGF-directed flare gas line
44: EGF-directed flare gas line
45: EGF-directed flare gas line
4X: EGF-directed flare gas line
50: temperature detector
51: auxiliary fuel regulation arithmetic device
52: air intake damper opening amount regulator
60: flare gas pressure detector
61: B to N flare gas supply/switching operation arithmetic device
70: safety valve detector
71: VDU/EGF flare gas switching operation arithmetic device
80: combustible gas reservoir

[Document Name] Claims

[Claim 1]

A flare gas combustion treatment system for combustion treatment of flare gas, the system comprising:

a VDU and an EGF; and

an information processor that controls the entire system, wherein

one end of a flare gas line, through which the flare gas is supplied, is connected to each of the VDU and the EGF,

a supply/shut-off device that allows/shuts off a flow of the flare gas and controls a flow rate of the flare gas is provided in the middle of a flare gas line toward the VDU and in the middle of a flare gas line toward the EGF,

when the flare gas is subjected to combustion treatment by the VDU, the information processor operates the supply/shut-off device for the EGF to close the flare gas line toward the EGF, and

when the flare gas is subjected to the combustion treatment by the EGF, the information processor operates the supply/shut-off device for the VDU to close the flare gas line toward the VDU or control the flow rate.

[Claim 2]

The flare gas combustion treatment system according to claim 1, wherein

the flare gas that has low concentration of a combustible content in the flare gas and is not self-combustible is subjected to the combustion treatment by the VDU.

[Claim 3]

The flare gas combustion treatment system according to claim 1 or 2, wherein

an air intake damper that draws air from outside is provided to the VDU,

the information processor controls an amount of auxiliary fuel when a temperature inside the VDU is increased to be equal to or higher than a preset temperature, and

in the case where the temperature inside the VDU is equal to or higher than the preset temperature even after the amount of the auxiliary fuel is controlled, the air intake damper is opened to draw the air into the VDU from the outside by natural suction.

[Claim 4]

The flare gas combustion treatment system according to any one of claims 1 to 3, wherein

when the temperature inside the VDU is equal to or higher than the preset temperature, the information processor operates the supply/shut-off device for the VDU to close the flare gas line toward the VDU or control the flow rate, and operates the supply/shut-off device for the EGF to open the flare gas line toward the EGF.

[Claim 5]

The flare gas combustion treatment system according to any one of claims 1 to 4, wherein

when a flare gas pressure becomes equal to or lower than a preset value of the flare gas pressure in association with a reduction in the flow rate of the flare gas, the information processor operates the supply/shut-off device for the EGF to close the flare gas line toward the EGF, and operates the supply/shut-off device for the VDU to open the flare gas line toward the VDU or control the flow rate.

[Claim 6]

The flare gas combustion treatment system according to any one of claims 1 to 5, wherein

another end of the flare gas line is connected to a combustible gas reservoir for storing the flare gas and provided with a safety valve that is actuated when being over-pressurized,

a distance from the one end to the other end of the flare gas line has such a length that it takes at least several seconds for the flare gas that has flowed out from the other end to reach the one end,

a safety valve detector that detects actuation of the safety valve is provided in the middle of the flare gas line near the combustible gas reservoir,

when a pressure inside the combustible gas reservoir becomes over-pressurized, and the safety valve is thereby actuated, the safety valve detector detects the actuation and outputs a signal indicating the actuation to the information processor, and

when receiving the signal, the information processor operates the supply/shut-off device for the VDU to close the flare gas line toward the VDU or control the flow rate, and operates the supply/shut-off device for the EGF to open the flare gas line toward the EGF.