

DESCRIPTION

TITLE BURNER

5

TECHNICAL FIELD

[0001] The present disclosure relates to a burner.

BACKGROUND

10 **[0002]** A burner using a fuel gas and a combustion-supporting gas is known.
For example, see Patent Literature (PTL) 1.

CITATION LIST

Patent Literature

15 **[0003]** PTL 1: JP 4261753 B2

SUMMARY

(Technical Problem)

20 **[0004]** A burner that burns fuel with an oxidizer is generally used as a heat
source in industrial furnaces, such as metal heating furnaces, glass melting
furnaces, and aluminum melting furnaces. Various fossil fuels are used as the
fuel, including solid fuels such as pulverized coal, liquid fuels such as
kerosene or heavy oil, or gaseous fuels such as natural gas or LPG. In an
industrial furnace, an object to be heated is heated by radiant heat transfer
25 from a flame generated by burning fuel.

[0005] When fossil fuels are used, the combustion exhaust gas contains a
large amount of CO₂, and therefore, in recent years, the use of ammonia has
been proposed.

30 **[0006]** Ammonia has the characteristic of not producing CO₂ when burned,
but since it contains no carbon, the flame radiation intensity is reduced and
the flame tends to be unstable due to a low combustion rate.

[0007] It is therefore an aim of the present disclosure to provide a burner that
uses ammonia as fuel and can ensure radiation intensity and flame stability.

(Solution to Problem)

35 **[0008]** An aspect of the present disclosure is as follows.

[0009] [1]

A burner that uses a fuel gas containing ammonia and a combustion-supporting gas having an oxygen concentration of 30 % or more.

[0010] [2]

The burner according to [1], comprising

5 a fuel gas supply pipe configured to supply the fuel gas and eject the fuel gas from a fuel gas ejection hole at a tip thereof; and

a combustion-supporting gas supply pipe provided radially outward from the fuel gas supply pipe so as to surround the fuel gas supply pipe and configured to supply the combustion-supporting gas and eject the
10 combustion-supporting gas from a combustion-supporting gas ejection hole at a tip thereof.

[0011] [3]

The burner according to [2], further comprising a burner body having a double-pipe structure formed by the fuel gas supply pipe and the
15 combustion-supporting gas supply pipe.

[0012] [4]

The burner according to [2] or [3], wherein

the fuel gas ejection hole is formed on an inner circumferential surface of the tip of the fuel gas supply pipe,

20 $d_1 < d_2$ at a position where $5 \times d_1 \leq L_1 \leq 10 \times d_1$, and

$\{(D_1 - d_1)/D_1\} \times 100 \leq 20$,

where d_1 is an inner diameter and D_1 is an outer diameter of the fuel gas supply pipe at the tip, and d_2 is an inner diameter at a position that is a distance L_1 from the tip.

25 **[0013]** [5]

The burner according to any one of [2] to [4], wherein

the combustion-supporting gas ejection hole is formed on an inner circumferential surface of the tip of the combustion-supporting gas supply pipe,

30 $d_3 < d_4$ at a position where $5 \times d_3 \leq L_2 \leq 10 \times d_3$,

where d_3 is an inner diameter of the combustion-supporting gas supply pipe at the tip and d_4 is an inner diameter at a position that is a distance L_2 from the tip,

the tip of the fuel gas supply pipe is located closer to a base end than
35 the tip of the combustion-supporting gas supply pipe, and

$L_3 < 5 \times d_3$,

where L_3 is a distance from the tip of the fuel gas supply pipe to the tip of the combustion-supporting gas supply pipe.

[0014] [6]

The burner according to any one of [2] to [5], further comprising
5 a burner body including the fuel gas supply pipe and the combustion-supporting gas supply pipe; and

a burner block having an opening in which the burner body is disposed, wherein

$$D_4 \leq D_5 \leq 1.1 \times D_4,$$

10 where D_4 is a maximum outer diameter of the combustion-supporting gas supply pipe at a portion thereof disposed at the opening, and D_5 is an inner diameter at a tip of the opening,

the tip of the combustion-supporting gas supply pipe is located closer to a base end than the tip of the opening, and

15 $0.2 \leq \{(D_5/2)^2 \times \pi\} \div L_4^2 \leq 0.5,$

where L_4 is a distance from the tip of the opening to the tip of the combustion-supporting gas supply pipe.

[0015] [7]

A heating furnace having installed therein at least one of the burner
20 according to any one of [1] to [6].

(Advantageous Effect)

[0016] According to the present disclosure, a burner that uses ammonia as fuel and can ensure radiation intensity and flame stability can be provided.

25 BRIEF DESCRIPTION OF THE DRAWINGS

[0017] In the accompanying drawings:

FIG. 1 is a cross-sectional view illustrating a heating furnace according to an embodiment of the present disclosure;

FIG. 2 is a partially enlarged view of the burner illustrated in FIG. 1;

30 FIG. 3 is a graph illustrating the relationship between the oxygen concentration of the oxidizer and the adiabatic theoretical flame temperature; and

FIG. 4 is a graph illustrating the relationship between the oxygen concentration of the oxidizer and the combustion rate.

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DETAILED DESCRIPTION

[0018] Hereinafter, embodiments of the present disclosure will be illustrated with reference to the drawings.

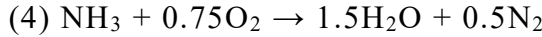
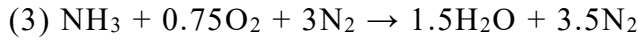
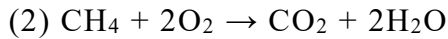
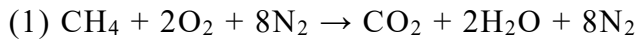
[0019] As illustrated in FIGS. 1 and 2, in one embodiment of the present disclosure, a heating furnace 6 has at least one burner 1. The heating furnace 6 has a furnace side wall 6a in which the burner 1 is installed. The burner 1 is embedded in the furnace side wall 6a. This arrangement of the burner 1 in the heating furnace 6 is not limiting. The burner 1 burns fuel gas in the internal space 6b of the heating furnace 6 to heat an object to be heated and to melt the object as necessary.

[0020] The burner 1 uses a fuel gas containing ammonia and a combustion-supporting gas having an oxygen concentration of 30 % or more.

[0021] According to the above configuration, a burner 1 that uses ammonia as the fuel gas and can ensure radiation intensity and flame stability can be achieved. The fuel gas is not particularly limited as long as it contains ammonia, but the fuel gas preferably contains ammonia as a main component (i.e., the ammonia component is more than 50 % and is 100 % or less). The combustion-supporting gas is not particularly limited as long as it has an oxygen concentration of 30 % or more, but oxygen-enriched air is preferably used so that the oxygen concentration in the combustion-supporting gas reaches 30 % or more.

[0022] The radiation intensity and flame stability of the burner 1 are related to the flame temperature and combustion rate, which in turn are related to the oxygen concentration of the combustion-supporting gas. For example, FIG. 3 illustrates how the oxygen concentration of the oxidizer (combustion-supporting gas) relates to the adiabatic theoretical flame temperature of the fossil fuel (methane) and ammonia, and FIG. 4 illustrates how the oxygen concentration of the oxidizer (combustion-supporting gas) relates to the combustion rate of the fossil fuel (methane) and ammonia. Thus, ammonia has a lower flame temperature and combustion rate than fossil fuels. In view of the above, it has been found that by setting the oxygen concentration of the combustion-supporting gas to 30 % or more, radiation intensity and flame stability sufficient for practical use in industrial furnaces can be ensured.

[0023] A comparison of the chemical equations for CH₄ (methane) and NH₃ (ammonia), which are the main components of common fossil fuels, during burning is as follows.



5 Equation (1) represents the case in which CH_4 is burned in air.

Equation (2) represents the case in which CH_4 is burned in oxygen.

Equation (3) represents the case in which NH_3 is burned in air.

Equation (4) represents the case in which NH_3 is burned in oxygen.

[0024] The CO_2 and H_2O contained on the right side of each equation are
10 known as radiative gases, and these gases contribute to the radiative
performance of the combustion flame. A comparison of the equations indicates
that the concentrations of the respective radiative gases are as follows, and
that changing the oxidizer from air to oxygen improves the radiation
performance of the flame. However, in equation (2), the CO_2 concentration in
15 the exhaust gas increases. In equation (3), the CO_2 concentration is zero, and
the concentration of the radiative gas is greater than in equation (1).
Furthermore, in equation (4), in which the oxidant is changed from air to
oxygen, the concentration of the radiative gas is further improved. Therefore,
it is clear that increasing the oxygen concentration of the oxidizer is effective
20 for ammonia, which has a low flame temperature.

[Table 1]

	Concentration (%)	
	CO_2	H_2O
Equation (1): CH_4 — air combustion	9.1	18.2
Equation (2): CH_4 — oxygen combustion	33.3	66.7
Equation (3): NH_3 — air combustion	0	30
Equation (4): NH_3 — oxygen combustion	0	75

[0025] The burner 1 includes a fuel gas supply pipe 2a and a
combustion-supporting gas supply pipe 2b. The fuel gas supply pipe 2a
25 supplies a fuel gas (preferably without premixing oxygen) and ejects the fuel
gas from a fuel gas ejection hole 2a1 at a tip thereof. The
combustion-supporting gas supply pipe 2b is provided radially outward from
the fuel gas supply pipe 2a so as to surround the fuel gas supply pipe 2a
(preferably, as illustrated in the drawings, to surround the tip of the fuel gas
supply pipe 2a, and so that a flow passage for the combustion-supporting gas
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is formed between the outer circumferential surface of the fuel gas supply pipe 2a and the inner circumferential surface of the combustion-supporting gas supply pipe 2b that is spaced apart from the outer circumferential surface over the entire circumference), and supplies a combustion-supporting gas (preferably without premixing fuel) and ejects the combustion-supporting gas from a combustion-supporting gas ejection hole 2b1 at a tip thereof. According to the above configuration, the burner flame can be supplied with fuel gas ejected from the fuel gas ejection hole 2a1 and combustion-supporting gas ejected from the combustion-supporting gas ejection hole 2b1, thereby achieving stable ammonia combustion while suppressing backfire. The fuel gas supply pipe 2a preferably surrounds the central axis O of the combustion-supporting gas supply pipe 2b as illustrated in the drawings and more preferably is provided coaxially with the combustion-supporting gas supply pipe 2b as illustrated in the drawings. In the present embodiment, the inner and outer circumferential surfaces of the fuel gas supply pipe 2a at the tip thereof and the inner and outer circumferential surfaces of the combustion-supporting gas supply pipe 2b at the tip thereof are each circular, but this example is not limiting.

[0026] The burner 1 has a burner body 2 having a double-pipe structure formed by the fuel gas supply pipe 2a and the combustion-supporting gas supply pipe 2b. According to the above configuration, radiation intensity and flame stability can be ensured with a simple structure.

[0027] The fuel gas ejection hole 2a1 is formed on the inner circumferential surface of the tip of the fuel gas supply pipe 2a, $d_1 < d_2$ at a position where $5 \times d_1 \leq L_1 \leq 10 \times d_1$, and $\{(D_1 - d_1)/D_1\} \times 100 \leq 20$, where d_1 is an inner diameter and D_1 is an outer diameter of the fuel gas supply pipe 2a at the tip, and d_2 is an inner diameter at a position that is a distance L_1 from the tip. According to the above configuration, since $d_1 < d_2$ at the position where $5 \times d_1 \leq L_1 \leq 10 \times d_1$, the flow passage of the fuel gas near the fuel gas ejection hole 2a1 narrows toward the fuel gas ejection hole 2a1, causing the supply pressure of the fuel gas to increase toward the fuel gas ejection hole 2a1. As a result, the supply pressure of the fuel gas at the fuel gas ejection hole 2a1 is made uniform, thereby improving the uniformity of the amount of fuel gas ejected from the fuel gas ejection hole 2a1. Furthermore, since $\{(D_1 - d_1)/D_1\} \times 100 \leq 20$, the distance between the outer circumferential surface of the flow passage of the fuel gas and the inner circumferential surface of the flow passage of the

combustion-supporting gas at the tip of the fuel gas supply pipe 2a becomes small enough for practical use, thereby enabling rapid mixing of the fuel gas and the combustion-supporting gas. Therefore, good flame stability as a result of good mixing can be achieved.

5 [0028] The combustion-supporting gas ejection hole 2b1 is formed on the inner circumferential surface of the tip of the combustion-supporting gas supply pipe 2b, $d_3 < d_4$ at a position where $5 \times d_3 \leq L_2 \leq 10 \times d_3$, where d_3 is the inner diameter of the combustion-supporting gas supply pipe 2b at the tip and d_4 is the inner diameter at a position that is a distance L_2 from the tip, the
10 tip of the fuel gas supply pipe 2a is located closer to the base end than the tip of the combustion-supporting gas supply pipe 2b, and $L_3 < 5 \times d_3$, where L_3 is the distance from the tip of the fuel gas supply pipe 2a to the tip of the combustion-supporting gas supply pipe 2b. According to the above configuration, since $d_3 < d_4$ at a position where $5 \times d_3 \leq L_2 \leq 10 \times d_3$, the flow
15 passage of the combustion-supporting gas narrows toward the combustion-supporting gas ejection hole 2b1, causing the supply pressure of the combustion-supporting gas to increase toward the combustion-supporting gas ejection hole 2b1. As a result, the supply pressure of the combustion-supporting gas at the combustion-supporting gas ejection hole
20 2b1 is made uniform, thereby improving the uniformity of the amount of combustion-supporting gas ejected from the combustion-supporting gas ejection hole 2b1. Furthermore, since the tip of the fuel gas supply pipe 2a is located closer to the base end than the tip of the combustion-supporting gas supply pipe 2b, and $L_3 < 5 \times d_3$, a mixing chamber 3 can be formed while
25 suppressing the possibility of backfire, thereby achieving even better mixing that results in even better flame stability. In the present embodiment, the fuel gas supply pipe 2a and the combustion-supporting gas supply pipe 2b each extend linearly in parallel to the central axis O at least in a range in which $0 \leq L_2 \leq 10 \times d_3$ is satisfied.

30 [0029] The burner 1 has a burner body 2 including the fuel gas supply pipe 2a and the combustion-supporting gas supply pipe 2b, and a burner block 4 having an opening 4a in which the burner body 2 is disposed (preferably coaxially as illustrated in the drawings). $D_4 \leq d_5 \leq 1.1 \times D_4$, where D_4 is the maximum outer diameter of the combustion-supporting gas supply pipe 2b at a
35 portion thereof disposed at the opening 4a, and d_5 is the inner diameter at a tip of the opening 4a. The tip of the combustion-supporting gas supply pipe 2b is

located closer to the base end than the tip of the opening 4a, and $0.2 \leq \{(d_5/2)^2 \times \pi\} \div L_4^2 \leq 0.5$, where L_4 is the distance from the tip of the opening 4a to the tip of the combustion-supporting gas supply pipe 2b. According to the above configuration, $D_4 \leq d_5 \leq 1.1 \times D_4$, the tip of the combustion-supporting gas supply pipe 2b is located closer to the base end than the tip of the opening 4a, and $0.2 \leq \{(d_5/2)^2 \times \pi\} \div L_4^2 \leq 0.5$. Consequently, the opening 4a of the burner block 4 forms a good combustion chamber 5 while protecting the burner body 2 from radiant heat from the installation environment, such as an industrial furnace. The burner 1 is not limited to a configuration having the burner block 4 and may, for example, be configured to have a water-cooled jacket instead of or in addition to the burner block 4. In the present embodiment, the opening 4a is configured as a circular through-hole, but this configuration is not limiting.

[0030] Although embodiments of the present disclosure have been described above, the present disclosure is not limited to the above-described embodiments, and the above-described embodiments can be modified in various ways without departing from the scope of the present disclosure.

REFERENCE SIGNS LIST

20	[0031]	1	Burner
		2	Burner body
		2a	Fuel gas supply pipe
		2a1	Fuel gas ejection hole
		2b	Combustion-supporting gas supply pipe
25		2b1	Combustion-supporting gas ejection hole
		3	Mixing chamber
		4	Burner block
		4a	Opening
		5	Combustion chamber
30		6	Heating furnace
		6a	Furnace side wall
		6b	Internal space
		d ₁	Inner diameter
		d ₂	Inner diameter
35		d ₃	Inner diameter
		d ₄	Inner diameter

	d ₅	Inner diameter
	D ₁	Outer diameter
	D ₂	Outer diameter
	D ₃	Outer diameter
5	D ₄	Outer diameter
	L ₁	Distance
	L ₂	Distance
	L ₃	Distance
	L ₄	Distance
10	O	Central axis

CLAIMS

[Claim 1] A burner that uses a fuel gas containing ammonia and a combustion-supporting gas having an oxygen concentration of 30 % or more.

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[Claim 2] The burner according to claim 1, comprising
a fuel gas supply pipe configured to supply the fuel gas and eject the fuel gas from a fuel gas ejection hole at a tip thereof; and

a combustion-supporting gas supply pipe provided radially outward
10 from the fuel gas supply pipe so as to surround the fuel gas supply pipe and configured to supply the combustion-supporting gas and eject the combustion-supporting gas from a combustion-supporting gas ejection hole at a tip thereof.

15 [Claim 3] The burner according to claim 2, further comprising a burner body having a double-pipe structure formed by the fuel gas supply pipe and the combustion-supporting gas supply pipe.

[Claim 4] The burner according to claim 2, wherein
20 the fuel gas ejection hole is formed on an inner circumferential surface of the tip of the fuel gas supply pipe,

$d_1 < d_2$ at a position where $5 \times d_1 \leq L_1 \leq 10 \times d_1$, and

$\{(D_1 - d_1)/D_1\} \times 100 \leq 20$,

where d_1 is an inner diameter and D_1 is an outer diameter of the fuel
25 gas supply pipe at the tip, and d_2 is an inner diameter at a position that is a distance L_1 from the tip.

[Claim 5] The burner according to claim 2, wherein
the combustion-supporting gas ejection hole is formed on an inner
30 circumferential surface of the tip of the combustion-supporting gas supply pipe,

$d_3 < d_4$ at a position where $5 \times d_3 \leq L_2 \leq 10 \times d_3$,

where d_3 is an inner diameter of the combustion-supporting gas supply
pipe at the tip and d_4 is an inner diameter at a position that is a distance L_2
35 from the tip,

the tip of the fuel gas supply pipe is located closer to a base end than

the tip of the combustion-supporting gas supply pipe, and

$$L_3 < 5 \times d_3,$$

where L_3 is a distance from the tip of the fuel gas supply pipe to the tip of the combustion-supporting gas supply pipe.

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[Claim 6] The burner according to claim 2, further comprising

a burner body including the fuel gas supply pipe and the combustion-supporting gas supply pipe; and

a burner block having an opening in which the burner body is disposed,

10 wherein

$$D_4 \leq D_5 \leq 1.1 \times D_4,$$

where D_4 is a maximum outer diameter of the combustion-supporting gas supply pipe at a portion thereof disposed at the opening, and D_5 is an inner diameter at a tip of the opening,

15 the tip of the combustion-supporting gas supply pipe is located closer to a base end than the tip of the opening, and

$$0.2 \leq \{(D_5/2)^2 \times \pi\} \div L_4^2 \leq 0.5,$$

where L_4 is a distance from the tip of the opening to the tip of the combustion-supporting gas supply pipe.

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[Claim 7] A heating furnace having installed therein at least one of the burner according to any one of claims 1 to 6.