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[54] **METHOD OF PREVENTING FORMATION OF HARMFUL COMBUSTION GASES IN COMBUSTION FURNACE**

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[51] **Int. Cl.** **F231 7/00**

[58] **Field of Search** .... 431/4, 9, 10, 115, 116, 431/2; 23/277 C

[56] **References Cited**

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[57] **ABSTRACT**

There is provided a method for considerably reducing the harmful constituents of exhaust gases ejected into the atmosphere from the combustion chamber of a combustion furnace such as a melting furnace, direct heating furnace, indirect heating furnace or reaction furnace when a mixture or fuel is burned therein. A novel feature of this method is that a mixture of oxygen and either an inert gas or the exhaust gas from the combustion chamber is substituted for practically the whole quantity of air fed to the combustion chamber to burn the fuel therein.

5 Claims, 1 Drawing Figure

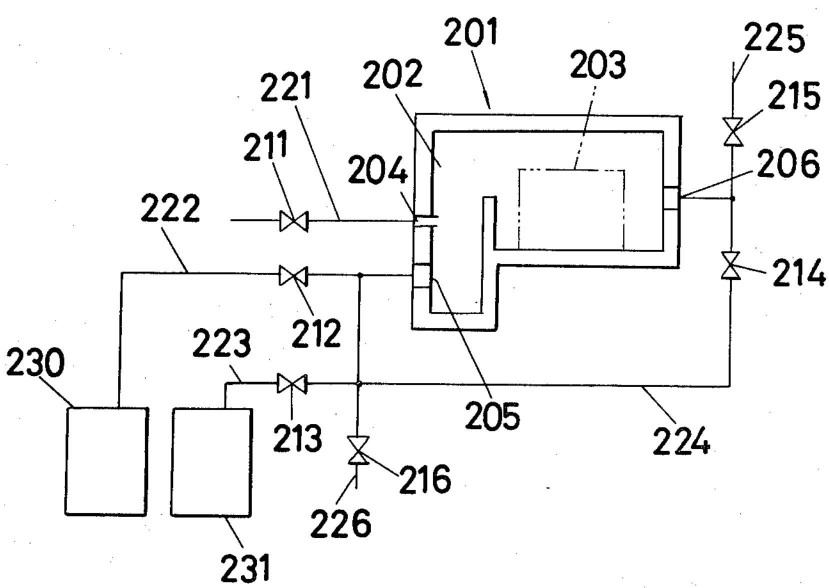
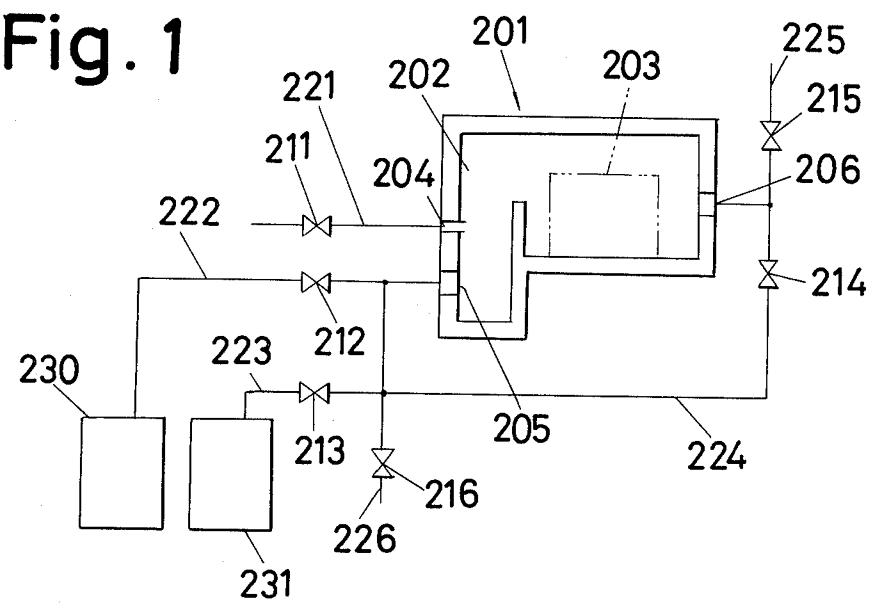


Fig. 1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METHOD OF PREVENTING FORMATION OF HARMFUL COMBUSTION GASES IN COMBUSTION FURNACE

BACKGROUND OF THE INVENTION

The present invention relates to a method for considerably reducing the amounts of the noxious combustion constituents of the exhaust gases ejected into the atmosphere from combustion chambers of various kinds.

Many different kinds of combustion furnaces in which coal, coke, petroleum, gas, etc. is burned, are widely used in the smelting and processing of iron and steel and various other metals, the manufacturing of gases, cokes, cement, glass, etc. and many other industrial fields. The exhaust gases emitted to the atmosphere from these combustion furnaces include harmful substances such as carbon monoxide (CO), hydrocarbons (HC's) and oxides of nitrogen (NOx), and increasingly strict control of the emission of these harmful gases has been demanded as the problem of so-called environmental sanitation. However, no industrially suitable effective measure for controlling these harmful gases, particularly nitrogen oxides has been developed and in the present circumstances, therefore, the operation of such combustion furnaces must be cut in case of emergency.

In view of the fact that said harmful constituents of exhaust gases are produced from the incomplete combustion of fuel, the inventor, after an experiment wherein an additional supply of oxygen was mixed into the air to be supplied into the combustion chamber of combustion furnace, found that, under the condition, nitrogen oxides tend to increase in quantity while carbon monoxide, hydrocarbons and soots decrease. The inventor further ascertained that the above phenomenon was attributable to the over-supplying of oxygen, which realized complete combustion of fuel on the one hand, and to the complete combustion itself in air containing a considerable quantity of nitrogen at high temperature, caused by complete combustion of fuel on the other. Thus, he hit upon the idea of carrying out the combustion of fuel without supplying the air, the best method to prevent the production of nitrogen oxides during the combustion of fuel in the combustion furnace. However, it has, according to the experiment made by the inventor, become known that the combustion of fuel does not always attain a state of stability, and tends to cause a high temperature in the combustion furnace when an additional supply of oxygen is mixed in greater quantities relative to those of the fuel supplied.

SUMMARY OF THE INVENTION

With a view to overcoming the foregoing difficulty, it is an object of the present invention to provide a method of preventing the formation of harmful combustion gases which can be applied easily and conveniently to the combustion chambers of various kinds of combustion furnaces and which is capable of not only effectively reducing the emission of harmful combustion products, e.g., carbon monoxide, hydrocarbons and nitrogen oxides, but also contributing to the improvement of combustion efficiency and the reduction of fuel consumption.

It is another object of the present invention to provide a method of preventing the formation of harmful combustion gases wherein a mixture of oxygen and either an inert gas, except nitrogen, or the exhaust gas emitted from a combustion chamber is supplied into the combustion chamber in place of practically the whole quantity of the air to be supplied to the combustion chamber, thereby preventing the production of nitrogen oxides (NOx) during the combustion of the fuel in the combustion chamber.

DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram showing one form of the apparatus for performing the method of this invention, wherein a mixture of oxygen and either an inert gas or the exhaust from a combustion chamber is supplied into the combustion chamber.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1 illustrating one form of an apparatus for performing the method of this invention, a combustion furnace **201** is of the ordinary type and it has a substantially closed combustion chamber **202.** In this type of direct heating furnace, a heating unit **203** is placed within the combustion chamber **202.** The combustion furnace **201** is provided with a fuel supply port **204,** a mixture supply port **205** and an exhaust port **206** which are arranged at suitable positions. A fuel such as petroleum, gas or pulverized coal is supplied from a fuel source (not shown) to the fuel supply port **204** by way of a pipe line **221** provided with a valve **211.** If coal or coke in pulverized or massive form is employed as fuel, a suitable fuel supply system may be provided.

The mixture supply port **205** is connected to an oxygen source **230** through a pipe line **222** having a valve **212** and it is also connected to an inert gas source **231** through a pipe line **223** having a valve **213.** The oxygen source **230** includes an oxygen storage means such as a high pressure oxygen bomb or low pressure oxygen container, or it may comprise an oxygen generator having a storage means and pressure means so that a predetermined amount of oxygen is supplied. The inert gas source **231** includes an inert gas storage means such as a high pressure inert gas bomb or low pressure inert gas container or it may comprise an inert gas producer having a storage means and pressure means so that a predetermined amount of inert gas is supplied. While the inert gas should preferably be carbon dioxide gas, any other rare gas such as xenon, argon, neon or helium or a mixture of more than two of these inert gases may also be used. However, such an inert gas as nitrogen gas that will produce harmful gases when subjected to elevated temperatures along with the fuel and oxygen should not be used. Further, while the oxygen and inert gas may be stored in liquid form, they should be vaporized and, if necessary, they should be preheated before they are supplied into the combustion chamber.

The exhaust port **206** is connected to the mixture supply port **205** through a pipe line **224** provided with a valve **214** and it also communicates with the atmosphere through a pipe line **225** provided with a valve **215.** On the other hand, the mixture supply port **205** communicates with the atmosphere through a pipe line **226** provided with a valve **216.**

While not shown in FIG. **1,** there are many other component parts that may be provided as the case may be. They include a flow regulating valve provided in the pipe line **221** to control the quantity of fuel supply, a flow regulating valve provided in the pipe line **222** to control the quantity of oxygen supply in accordance with the quantity of fuel supplied, a flow regulating valve provided in the pipe line **223** to control the quantity of inert gas supply in accordance with the quantity of oxygen supplied, a temperature detecting means and a pressure detecting means provided in each of the pipe lines **222, 223** and **221** for detecting the temperature and pressure of the gas flowing therethrough, a control circuit comprising operators, etc., for supplying control signals to each of the flow regulating valves in accordance with the detected temperature and pressure, an air blower provided in each of the pipe lines **224** and **226,** a mixing chamber provided at the entry side of the mixture supply port **205** to mix the oxygen, inert gas or exhaust gas, and a heat exchanger provided at the outlet side of the exhaust port to preheat the oxygen, inert gas or the mixture thereof and the fuel. The combustion furnace **201** may consist of an indirect heating furnace or any one of many different types of combustion furnaces. If it comprises an open type furnace, it should preferably be arranged so that the exhaust is supplied to the mixture supply port in such a manner that the mixing of the air is minimized, or if this is difficult, it may be arranged so that the use of the exhaust is eliminated.

With the apparatus constructed as described above, if the valves **212, 213** and **214** are closed and the valves **211, 215** and **216** are opened to supply the air and fuel into the combustion chamber **202,** the usual combustion with the air takes place in the same manner as in the conventional apparatus and thus the exhaust gases containing harmful substances are emitted through the pipe line **225.** Consequently, the valve **216** and the pipe line **226** are provided for emergency purposes as the occasion demands. Thus, if they are provided, the valve **216** is normally kept in the closed condition and it is opened temporarily only when it is impossible to supply a sufficient quantity of the oxygen from the oxygen source **230,** but the continued combustion is required.

When there is residual air in the combustion furnace **201** during the starting period, the valves **211** and **214** are closed and then the valves **212, 213** and **215** are opened to substitute the mixture for the air in the combustion furnace **201.** Thereafter, the valves **211** and **212** are opened to supply the fuel and the inert gas containing the proper quantity of the oxygen corresponding to the fuel quantity supplied, i.e., the mixture into the combustion chamber **202.** When combustion takes place in this way, the fuel is almost completely burned in the combustion chamber **202,** and since no nitrogen is supplied, the amounts of harmful substances contained in the exhaust gases emitted through the pipe line **225** are reduced considerably as compared with the conventional apparatus where the air is used. In this case, if the valve **214** is opened and the valve **213** is closed while suitably decreasing the opening of the valve **215** to recirculate the exhaust to be supplied into the combustion chamber **202** in place of the inert gas, substantially complete combustion takes place as previously described and thus the exhaust gases emitted through the pipe line **225** contain very small quantities of the harmful substances. In other words, if the air in the combustion chamber **202** is replaced with the inert gas or the inert gas containing the proper quantity of the oxygen during the starting period, thereafter the whole or part of the inert gas may be replaced with the recirculating exhaust with the result that the heat loss decreases as the proportion of the exhaust gas increases and moreover a saving in the inert gas consumption may be ensured. Further, even when the proportion of the oxygen in the mixture is slightly lower than that of the oxygen in the air, a sufficiently good combustion can generally take place.

Table **1** shows by way of example the results of the tests conducted using an ordinary metal heating furnace of about 9,000l volume as combustion furnace. The fuel used was a commercially available petroleum and the percentage (weight percentage) of the O_2 in the mixture was gradually changed from 5 to 30 percent with the remainder being CO_2 or the exhaust. After the combustion conditions and the furnace temperatures became practically stable, the relative percentages of the contents of the harmful constituents, i.e., nitrogen oxides (NOx), carbon monoxide (CO) and hydrocarbons (HC's) in the exhaust gases and the furnace temperatures were measured. As shown in case B in the table, when the air was used, the percentages of the NOx, CO and HC contents were 25,000, 8,500 and 1,500 ppm, respectively. On the contrary, as shown in Case A, when the mixtures according to the present invention were used, the percentages of the contents of the harmful constituents decreased with increase in the percentage of the O_2 content up to about 20 percent after which the percentage of the harmful emissions remained unchanged. As compared with the results obtained with the use of the air, the percentages of the NOx, CO and HC contents were reduced to about **1/250, 1/10.6** and **1/15,** respectively. On the other hand, when the percentage of the O_2 content was higher than 15 percent, the furnace temperature showed about 1100°C which was approximately the same as that obtained with the use of the air. In other words, if the percentage of the oxygen content is maintained at about 15 percent, the required furnace temperature may be ensured and in this case the percentages of the NOx, CO and HC contents may be considerably reduced to about **1/250, 1/6.4** and **1/5,** respectively, as compared to those obtained when the air was used.

Table **2** shows by way of example the results of the similar tests conducted using a boiler having a fire bed area of about 10 m^2 as a combustion furnace and a commercially available petroleum as fuel. It was confirmed that the results of the tests showed practically the same tendency with the results of the tests of Table **1**, although some slight differences were noted in the relative percentages of the harmful emissions due to the relatively lower furnace temperatures. It is self-evident that the particularly noticeable reductions in the percentages of the NOx contents are attributable to the elimination of the use of air in both cases.

TABLE 1

	Mixture (% by weight)		Relative percentages of the harmful constituents in exhaust gases (ppm)			Furnace temperature (°C)
Case	O_2	CO_2 or exhaust	NO_x	CO	HC	
	5	95	Unstable combustion)			—
	8	92	3500	2200	1000	950
	10	90	300	800	550	1000
	13	87	100	650	350	1050
A	15	85	100	550	300	1100
	18	82	100	400	150	1100
	20	80	100	330	100	1100
	25	75	100	330	100	1100

TABLE 1-Continued

Case	Mixture (% by weight) O_2	CO_2 or exhaust	Relative percentages of the harmful constituents in exhaust gases (ppm) NO_x	CO	HC	Furnace temperature (°C)
	30	70	100	330	100	1100
B	Air		25000	3500	1500	1100

TABLE 2

Case	Mixture (% by weight O_2	CO_2 or exhaust	Relative percentages of the harmful constituents in exhaust gases (ppm) NO_x	CO	HC	Fire bed temperature (°C)
	5	95	(Unstable combustion)			—
	8	92	200	11000	150	600
	10	90	150	5500	100	620
	13	87	100	2700	70	650
A	15	85	50	1150	50	680
	18	82	50	500	50	700
	20	80	50	350	30	700
	25	75	50	350	30	700
	30	70	50	350	30	700
B	Air		22000	13600	300	700

It will thus be seen from the foregoing description that in accordance with the present invention, as described hereinbefore, practically the whole quantity of the air to be supplied into the combustion chamber of a combustion furnace or the like, is replaced with the supply of a mixture of oxygen and either an inert gas other than nitrogen or the exhaust from the combustion chamber, and there is thus provided a method for preventing the formation of harmful combustion products in a combustion furnace which is capable of considerably reducing the amounts of harmful constituents, e.g., nitrogen oxides, carbon oxides and hydrocarbons contained in the exhaust gases emitted to the atmosphere from the combustion chamber of the combustion furnace.

The present invention is not to be limited to the specific embodiments described hereinafter, but is applicable within the principles enunciated herein to various kinds of combustion furnaces.

What is claimed is:

1. In a process wherein a fuel is combusted, the improvement which comprises combusting said fuel in an atmosphere which is substantially free of chemically uncombined nitrogen so as to reduce the quantities of harmful combustion constituents in the exhaust gases generated during combustion of said fuel, said atmosphere comprising a mixture of oxygen and at least a portion of said exhaust gases.

2. In a process wherein a fuel is combusted, the improvement which comprises combusting said fuel in an atmosphere which is substantially free of chemically uncombined nitrogen so as to reduce the quantities of harmful combustion constituents in the exhaust gases generated during combustion of said fuel, said atmosphere comprising a mixture of oxygen and an inert gas.

3. A process as defined in claim **2,** wherein said inert gas comprises at least one of the gases selected from the group consisting of helium, argon, neon, xenon and carbon dioxide.

4. A process as defined in claim **2,** wherein said atmosphere comprises a minimum of approximately 15 percent by weight of oxygen.

5. In a process wherein a fuel is combusted, the improvement which comprises combusting said fuel in an atmosphere which is substantially free of chemically uncombined nitrogen so as to reduce the quantities of harmful combustion constituents in the exhaust gases generated during combustion of said fuel, said atmosphere comprising a maximum of approximately 20 percent by weight of oxygen.

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