United States Patent [19]

Hirose

[11] **3,876,362**

[45] **Apr. 8, 1975**

[54] **METHOD OF COMBUSTION**

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[22] Filed: **Mar. 18, 1974**

[21] Appl. No.: **452,344**

[30] **Foreign Application Priority Data**

Apr. 23, 1973 Japan 48-045058

[52] **U.S. Cl.** **431/9**; 431/115; 431/252; 431/353

[51] **Int. Cl.** **F23m 9/00**

[58] **Field of Search** 431/8, 9, 10, 252, 353, 431/115, 116; 239/DIG. 7

[56] **References Cited**

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[57] **ABSTRACT**

The method of combustion in which fuel is injected at a high velocity through a high pressure air or steam atomizing type burner secured on a cover plate fixed at the front end of the burner tile structure.

The fuel stream being deflected to the specific wall of the burner tile structure by Coanda Effect and high temperature combustion gas being induced from the combustion space towards the wall of the burner tile structure opposite the deflected fuel stream and diffused in the fuel stream, the fuel is gasified by heat of the high temperature combustion gas before the stream of fuel is delivered into the combustion space.

14 Claims, 3 Drawing Figures

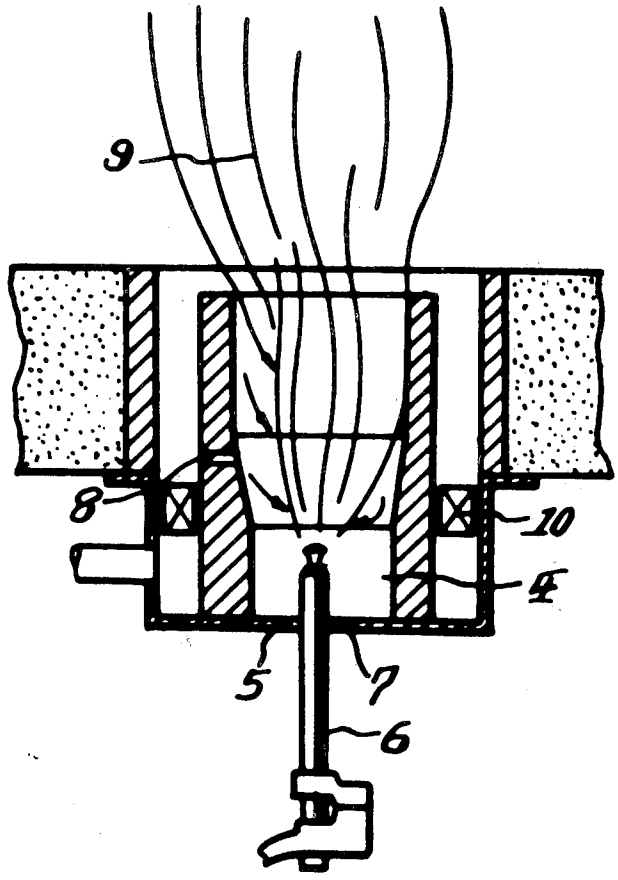


Fig. 1

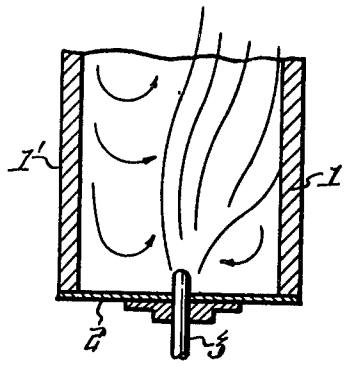


Fig. 2

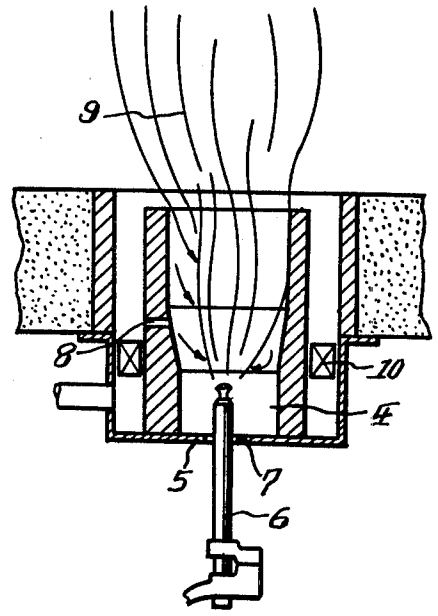
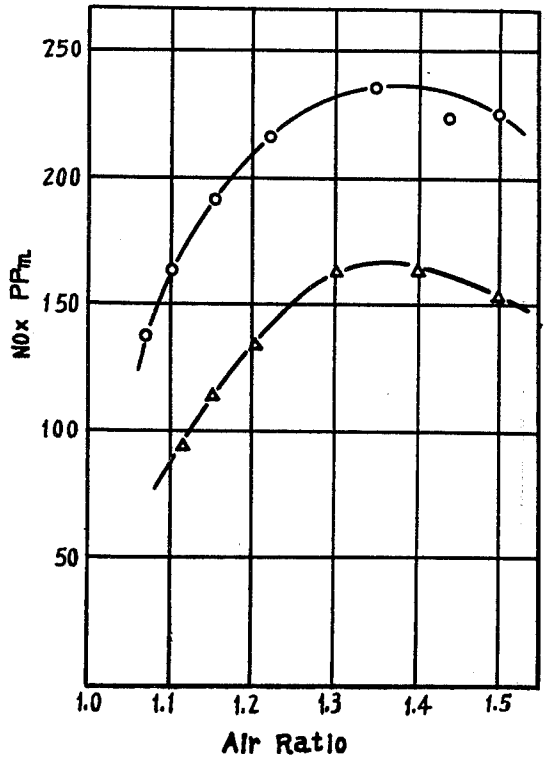


Fig. 3



METHOD OF COMBUSTION

BACKGROUND OF THE INVENTION

NOx is the prime agent of photochemical smog, therefore, it is desired to reduce the NOx generating rate in combustion.

It is the well known method of reducing NOx generating rate in controlling combustion by one of the following principles.

a: reduction of flame temperature

b: reduction of oxygen and nitrogen concentration

c: reduction of residence time of combustion gas in high temperature atmosphere.

In the practical application of those principles, it is the usual method.

1. to reduce flame temperature by circulating exhaust gas,
2. to apply two stage combustion which requires less oxygen and nitrogen for combustion,
3. to reduce flame temperature by injecting water into the combustion chamber and
4. to apply the multiple nozzle burner generally called as off-stoichiometric burner.

However, those methods have such disadvantages as in the method (1), in order to circulate exhaust gas at an adequately proportional ratio, a hot air fan and a regulating device must be provided as additional equipment requiring higher manufacturing cost and more sensitive operation due to the particular balance of pressure between the wind box and the combustion chamber, in the method (2), a larger combustion device is necessary for the two stage combustion and furthermore, two stage combustion is liable to generate large quantities of soot, in the method (3), although water injection is the simplest method to reduce flame temperature, it is the disadvantage that in order to reduce NOx generating rate to a satisfactorily low degree large quantities of water must be injected into the combustion chamber and that large quantities of water reduces heat efficiency and also that water is liable to corrode the flue and smoke passage and in the method (4), the multiple nozzle burner is applicable only to such a combustion device as a large boiler for the steam generator which usually is provided with plural burners.

SUMMARY OF THE INVENTION

It is, therefore, an object of the invention to provide the method of combustion with which all those disadvantages of the conventional method described above are overcome without providing any additional device, but simply by applying specific effect of the high velocity stream of fuel.

According to the invention, the fuel is injected at a high velocity into the burner tile structure, then the stream of fuel is deflected and the high temperature combustion gas is induced from the combustion space to the burner tile structure by the specific effect of high velocity stream of fuel. This high temperature combustion gas is diffused in the stream of fuel so that the fuel is gasified before combustion.

Thus by means of simple combustion device, NOx generating rate is reduced by half and at the same time uniform and low temperature complete combustion is attained with considerably reduced excess air.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagramatic illustration of generation of Coanda Effect applied to the invention.

FIG. **2** is a schematic illustration of the burner tile structure and adjacent devices according to the invention.

FIG. **3** is a graphical representation of converted NOx generating rate making a comparison between the method of the invention and the conventional single stage combustion method for various excess air ratios.

DETAILED DESCRIPTION OF THE INVENTION

As the object of the invention is attained by taking advantage of Coanda Effect caused by high velocity stream of gas, the invention will be readily understood by the explanation of Coanda Effect and incidental phenomena prior to the detailed explanation of the invention.

Referring to FIG. **1**, a cylindrical structure constructed of side walls **1** and **1'** is sealed at the front end by a cover plate **2** at the center of which an injection nozzle **13** is secured so as to inject gas coaxially with the cylindrical structure at a velocity as high as sonic velocity. Although gas is injected coaxially with the cylindrical structure, the stream of gas is deflected to one side of the side wall, for instance to the wall **1**, by some slight disturbance so that some part of the stream of gas flows being interfered by the surface of the wall **1**.

This phenomenon is designated as Coanda Effect.

Coanda Effect is stabilized so as not to deflect the stream of gas indefinitely but to deflect steadily to the preferred direction by adequately providing air inlets for the cover plate **2** or for the wall of the cylindrical structure or by some other suitable means.

As a result of Coanda Effect, air is induced from an open end of the cylindrical structure towards the side wall **1'** opposite to the wall **1** as shown by arrows in FIG. **1** at approximately a constant rate, then quickly is diffused in the stream of gas.

Referring now to FIG. **2**, there is shown an apparatus for further carrying out the method of the invention.

The front end of the burner tile structure **4** is closed by a cover plate **5**, at the center of which a high pressure type gas burner or a steam atomizing type oil burner **6** is secured.

Fuel, mixture of fuel and steam or mixture of fuel and air is injected through the burner **6** at a velocity near to sonic velocity.

The stream of fuel is deflected to a preferred side of the burner tile structure **4** by Coanda Effect, therefore, the stream of fuel flows into the combustion space **9** being interfered with the surface of the burner tile structure. Coanda Effect is controlled so as to stabilize the direction of deflection of the stream of fuel by appropriately providing air inlets **7** or **8** for the burner tile structure **4** or the cover plate **5** respectively or by giving a specific shape to the burner tile structure. High temperature combustion gas is induced from the combustion space **9** to the burner tile structure **4** towards the opposite side of the deflected stream of fuel as shown by arrows at a constant rate. This combustion gas is quickly diffused into the stream of fuel promoting endothermic gasification of fuel.

The gasified fuel is ignited and burns quickly in the combustion space **9**.

Thus the factors of the invention are, Coanda Effect caused by the stream of fuel injected into the burner tile structure **4** at a high velocity, induction of the high temperature combustion gas into the burner tile structure from the combustion space caused by stabilized Coanda Effect and quick endothermic gasification of fuel effected by the heat of the high temperature combustion gas induced into the burner tile structure and diffused in the stream of fuel. As the effect of those factors, fuel burns quickly and uniformly in the combustion space **9** when the spinning stream of combustion air is introduced circumposing the fuel stream at the open end of the burner tile structure **4** by introducing air through the duct at the left of plate **5** and along the outer wall of tile **4** past elements **10.**

Coanda Effect is stabilized, as described above, by providing the air inlets **7** or **8** or otherwise, by providing a cut out for the preferred position of the burner tile structure to induce smoothly the combustion gas into the burner tile structure.

An experimental combustion according to the invention showed that the measured quantity of the high temperature combustion gas induced into the burner tile structure is 50 to 65 percent of the theoretical amount of air, and that the high temperature combustion gas is induced into the burner tile structure at approximately a constant rate and is diffused in the fuel stream causing uniform endothermic gasification of fuel, therefore, complete combustion is performed in the combustion space with relatively reduced excess air and that the flame temperature is considerably lower degree of about 1,200°C as compared with the flame temperature of 1,350°C in the conventional single stage combustion.

Thus the combustion according to the invention being performed, the NOx generating rate is remarkably reduced.

FIG. **3** is a graph showing converted values of NOx generating rate for various excess air ratios, measured in the comparative combustion experiment between the method of the invention and the conventional method. The graph shows that NOx generating rate according to the method of the invention is approximately 40 percent lower than that of the conventional method for every excess air ratio, therefore, it may well be inferred that NOx generating rate is reduced by half by the method of the invention as the method of the invention requires less excess air for the complete combustion.

The term "converted value of NOx generating rate" is defined by the equation;

(converted value of Nox generating rate) = (excess air ratio) X (actual amount of NOx exhausted)

As the complete combustion of the fuel is performed by the method of the invention, less soot is generated.

The combustion test using B and C grade heavy oil showed that the amount of soot generated by the combustion according to the method of the invention is apparently less than which generated by the combustion according to the conventional method.

NOx generating rate can be reduced further by lowering flame temperature by circulating and mixing exhaust gas with combustion air.

What is claimed as new and desired to be secured by Letters Patent is:

1. The method of combustion for reducing NOx generating rate comprising; injection of fuel, mixture of fuel and steam or mixture of fuel and air at a high velocity through a high pressure type gas burner or a high pressure steam atomizing type oil burner secured on a cover plate fixed at the front end of the burner tile structure comprising deflection of the fuel stream to a selected direction in the burner tile structure by Coanda Effect, stabilization of the deflection of the fuel stream to cause the fuel stream to flow along a specific wall of the burner tile structure, induction of the high temperature combustion gas from the combustion space, positioned in the back of the burner tile structure, towards the wall of the burner tile structure opposite the wall along which the deflected fuel stream flows and diffusion of the induced high temperature combustion gas in the fuel stream promoting endothermic gasification of fuel.

2. The method of combustion comprising:

injecting fuel from a nozzle through a cover plate,

deflecting the injected fuel toward a wall,

drawing high temperature combustion gas from a combustion space toward the injected fuel,

mixing the combustion gas with the injected fuel,

flowing mixed combustion gases and injected fuel toward the combustion space from a space near the wall,

adding oxygen to the fuel and combustion gas mixture, and

igniting the mixture in the combustion space.

3. The method of claim **2** wherein the injecting step further comprises injecting the fuel into a space surrounded by a wall, and wherein the deflecting step comprises deflecting the fuel toward a portion of the wall.

4. The method of claim **2** wherein the deflecting step comprises admitting a gas opposite the wall.

5. The method of claim **2** wherein the deflecting step further comprises admitting air through the end plate.

6. The method of claim **2** wherein the drawing step comprises drawing combustion gas into a space near the nozzle opposite the wall.

7. The method of claim **2** wherein the injecting step further comprises injecting fuel into a space laterally surrounded by a wall, wherein the deflecting step comprises deflecting fuel toward a portion of the wall by a Coanda Effect, wherein the drawing step comprises drawing combustion gas into the space surrounded by the wall in an area opposite the portion of the wall toward which the fuel is directed, and wherein the flowing step comprises flowing the mixed combustion gas in a fuel outward from a space surrounded by the wall opposite from the nozzle.

8. The method of claim **5** wherein the deflecting step further comprises admitting oxygen into the space laterally surrounded by the wall in an area remote from the portion of the wall toward which fuel is deflected.

9. The method of claim **5** further comprising admitting oxygen to the combustion space around an exterior of the wall.

10. Fuel combustion apparatus comprising a frame, mounting means connected to the frame for mounting the frame on a fuel burning device having a combustion space, an end plate connected to the frame and having an opening, a fuel injection nozzle mounted in the opening in the end plate, a wall means mounted on the frame and positioned slightly spaced from the opening

in the end plate and mounted at an angle to the end plate, fuel deflection means connected to the frame for deflecting fuel from the nozzle toward the wall means, and combustion gas admission means connected to the frame and positioned between the end plate and the combustion space and mounted opposite the wall means for admitting combustion gas from the combustion space toward fuel and toward the wall means, whereby combustion gas and fuel are mixed in a space generally between the wall means and the admission means before flowing into the combustion space.

11. The apparatus of claim **10** further comprising a continuous enclosure wall mounted perpendicularly on the end plate and wherein the wall means comprises a portion of the enclosure wall, and wherein the admission means comprises an open space along a second portion of the enclosure wall opposite the portion toward which fuel is deflected.

12. The apparatus of claim **11** further comprising an opening in the enclosure wall adjacent the second portion for admitting air and for deflecting fuel toward the first wall portion.

13. The apparatus of claim **11** further comprising an opening in the end plate adjacent the nozzle for admitting air for augmenting deflection of the fuel toward the first wall portion.

14. The apparatus of claim **11** further comprising air admission means externally surrounding the wall for flowing air around the enclosure wall and into the combustion space surrounding a mixture of fuel and combustion gases flowing from the enclosure wall into the combustion space.

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