HEATING FURNACE PROVIDED WITH HIGH VELOCITY GAS BURNERS

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ABSTRACT

A high velocity gas burner has a combustion chamber. A tapered outlet nozzle is formed at one end of the combustion chamber and has a cross-sectional area smaller than that of the combustion chamber. The chamber also has an air inlet. An air flow equalizing plate having a number of air passage holes therein is disposed within the combustion chamber adjacent the air inlet, and a fuel inlet means extends into the chamber adjacent the air inlet and the air flow equalizing plate.

7 Claims, 11 Drawing Figures
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HEATING FURNACE PROVIDED WITH HIGH VELOCITY GAS BURNERS

This invention relates to a high velocity gas burner and a heating or heat-treating apparatus provided with such a gas burner. The term "heating furnace" as used hereinafter refers to such a heating apparatus and to such a heat-treating apparatus.

A first object of the present invention is to obtain a high temperature, high velocity hot gas stream by conducting high fuel throughput combustion in a combustion chamber of a gas burner, without attaching a special device to said gas burner.

A second object of the invention is to modify a conventional heating furnace in a manner such that it is adapted to use such a high velocity gas burner and to enable said gas burner to exhibit its characteristic features in said furnace, thereby to simplify the heating furnace and improve the temperature distribution in said heating furnace.

The construction, function and effectiveness of the present invention will be described in detail hereinafter with reference to the accompanying drawing, in which:

FIGS. 1a and 1b are a vertical cross-sectional view and a partial front elevation view of an embodiment of the high velocity gas burner according to the invention;

FIGS. 1c and 1d are similar views of a slightly modified embodiment of the gas burner;

FIG. 2 is a fragmentary transverse cross-sectional view of an embodiment of a heating furnace provided with the high velocity gas burner of FIGS. 1a and 1b;

FIG. 3 is a cross-sectional view taken on the line III—III of FIG. 2;

FIG. 4 is a vertical cross-sectional view of another embodiment of a heating furnace provided with the high velocity gas burner of FIGS. 1c and 1d;

FIG. 5 is a side elevation view of still another embodiment of a heating furnace provided with the high velocity gas burner of the invention;

FIG. 6 is a cross-sectional view taken on the line VI—VI of FIG. 5;

FIG. 7 is a vertical cross-sectional view of still another embodiment of a heating furnace comprising in combination the high velocity gas burners of the invention and low velocity gas burners; and

FIG. 8 is a cross-sectional view taken on the line VIII—VIII of FIG. 7.

Referring first to FIGS. 1a—1b, reference numeral 1 designates a combustion chamber of a gas burner according to the invention defined by a burner tile 2 and at one end of the combustion chamber is formed a tapered nozzle 3 having a cross-sectional area smaller than that of the combustion chamber 1. The tapered nozzle 3 may be formed on the center line of the burner shown in FIGS. 1c and 1d, or at right angles or a suitable angle to said center line as shown in FIGS. 1a and 1b. By directing the nozzle 3 as described above, the burner can be mounted at a desired position in a heating furnace as will be described later, without its operation being hampered. The nozzle end preferably has a slit-like shape as shown, because the slit-like shape is advantageous over a circular shape with the same cross-sectional area in that the surface area of the jet of gases discharged from the nozzle can be made larger and in that the jet of gases expands greatly when the gas burner is mounted in a heating furnace. As a result of positioning the nozzle 3 at one end of the combustion chamber 1, a back flow of combustion gases is formed within the combustion chamber in a direction reverse to the jetting direction of the combustion gases, which provides for thorough mixing of fuel gas and air, and also smooth high fuel throughput combustion. Reference numeral 4 designates an air flow equalizing plate having a number of air passage holes 5 formed therein. The air flow equalizing plate 4 is connected to the inner end of a gas pipe 6 extending along the center line of the burner and located within the combustion chamber 1. While in the embodiment shown, the air flow equalizing plate 4 has a cross-sectional shape which expands in the direction of jetting, i.e., into chamber 1, it may be at right angles to the center line of the burner. Further, the angle of the air flow equalizing plate 4 to the center line of the burner can be changed according to the purpose of the high velocity gas burner of the invention. This air flow equalizing plate 4 serves to promote mixing of the fuel gas with air and also to retain flames therein or throughout. Namely, the presence of a large number of the air passage holes 5 in the air flow equalizing plate 4 causes the combustion region to be shifted according to the quantity of fuel gas supplied. For instance, when the quantity of fuel gas is small relative to the quantity of air, the fuel gas burns near the air passage holes 5, whereas when the quantity of fuel gas is large relative to the quantity of air, the fuel gas burns over the entire surface of the air flow equalizing plate 4.

This means that a stable combustion can always be obtained no matter whether the quantity of fuel gas is large or small relative to the quantity of air and the fuel gas can be completely burned. In other words, a stable and complete combustion can be obtained when the fuel gas and air are mixed at the theoretical mixing ratio for complete combustion as well as when the quantity of air is excessively large relative to the quantity of fuel gas. Reference numeral 7 designates a pilot burner around which the gas pipe 6 is concentrically positioned and so constructed as to form a pilot flame inside the air flow equalizing plate 4. With such a construction, the pilot burner 7 can positively ignite the fuel-air mixture in the combustion chamber 1. Further, since the pilot flame is formed inside the air flow equalizing plate 4, overheating of the subject high velocity burner body, which would otherwise be caused by the pilot flame, can be avoided. This is advantageous in prolonging the useful life of the high velocity gas burner.

With the construction described above, the fuel gas is introduced from a gas inlet port 8 through the gas pipe 6 into the inside of the air flow equalizing plate 4, namely into the combustion chamber 1. On the other hand, air is introduced from an air inlet port 9 through the air passage holes 5 into the combustion chamber 1. The fuel gas and air are mixed and ignited by the pilot burner 7. Thus, the combustion is commenced. Since the cross-sectional area of the nozzle 3 is smaller than that of the combustion chamber 1 as stated previously, the heat generated in the combustion chamber by the fuel throughput in this case reaches as high as 5,000 - 20,000 × 10^4 Kcal/m^3/hr. Upon completion of the combustion in the combustion chamber, the resultant combustion gases are jetted from the nozzle 3 in the form of
a hot gas stream. The velocity of the hot gas stream is as high as 100 - 500m/second. The high velocity gas burner of the invention is capable of excess air ratio combustion as stated above and a satisfactory combustion can be obtained even at an excess air ratio of 5,000 percent. Therefore, the temperature of the combustion gases jetting from the nozzle 3 is not always high. The combustion gases can be discharged as a stream of warm gas, for example, at a temperature of 100° C. This is advantageous in that when the gas burner is mounted in a heating furnace, local heating of the furnace can be avoided and a uniform temperature distribution can be obtained within said furnace.

FIGS. 2 to 8 show heating furnaces comprising the subject high velocity gas burner. In FIGS. 2 and 3, reference characters a1 - a4 designate the high velocity gas burners of the invention each having the nozzle directed at right angles to the center line of the burner. As shown, these high velocity gas burners a1 - a4 are longitudinally mounted in the opposite side walls of the furnace body. Reference numeral 10 designates curved portions formed on the inner surface of the furnace wall at locations forwardly of the nozzle openings of the respective gas burners.

With the construction described above, the high temperature, high velocity hot gas stream jetting from each of the high velocity gas burners a1 - a4 circulates within the furnace as indicated by the arrows in FIG. 2, while drawing with them the gases in the furnace at the time of jetting. If, in this case, a projection 11 is provided forwardly of each of the high velocity gas burners a1 - a4, a part of the hot gas streams jetting from the gas burners a1 - a4 is directed towards the central portion of the furnace, and the other part thereof is accelerated by being drawn by the gas streams jetting from the successive gas burners a2 and a3 and directed towards the gas burners a2 and a4 upon being deflected 90° by the curved portions 10 respectively, as indicated in FIG. 2. Since the high temperature, high velocity hot gas streams circulate within the furnace while drawing the gases in said furnace as stated above, the gas temperature within the furnace is made uniform and thus the temperature distribution in the furnace is improved.

In addition, the hot gas streams when deflected by the curved portions 10, form hot gas curtains, so that the interior of the furnace is completely blocked off from the exterior even when a door 12 is opened. The remarkable advantage brought about by the hot air curtains thus formed, is that a desired number of heating zones 13, 14 ... can be successively formed longitudinally of the furnace, providing for zone control, or otherwise the entire furnace can be used as a single heating zone 13. The above-described advantage of the hot air curtains can similarly be obtained with a single heating zone. Whether the heating furnace has a plurality of heating zones or a single heating zone, the number of the high velocity gas burners to be mounted in the furnace and the formation of the projections 11 can be determined according to the purpose of use of the heating furnace. While in the embodiment of FIGS. 2 and 3, the high velocity gas burners are mounted in a horizontal position, it is to be understood that they may be mounted in a vertical position in the top wall of the furnace as shown in FIG. 4 or at any other locations of the furnace at a suitable angle of inclination. Namely, by suitably selecting the positions and locations of the gas burners, it is possible to circulate the gases in a horizontal plane as shown in FIG. 2, in a vertical plane as shown in FIG. 4, along the diagonal lines randomly by aligning the axes of the nozzles with said diagonal lines or randomly by directing the nozzles of opposed gas burners against each other. However, the curved portions 10 must be formed on the inner surface of the furnace forwardly of nozzles of the respective burners in any case.

Referring to FIGS. 5 and 6, there is shown a furnace comprising the gas burners of the invention so arranged as to attain uniform hot gas flow distribution as well as the heat distribution compensation peculiar to the car bottom furnace. Reference numeral 15 designates a plurality of grooves formed in the side walls of the furnace, the high velocity gas burners a6 of the invention are mounted alternately in the opposite side walls of the furnace so that the high temperature, high velocity hot gas streams jetting from the respective gas burners will pass through the respective grooves 15. In this case also, curved portions 10 must of course be formed on the inner surfaces of the side walls at locations opposite to the respective gas burners a6.

The hot gas stream jetting from each of the high velocity gas burners a6 passes through a groove 15 while drawing the gases within the furnace and is deflected by the curved portion 10 opposite to the gas burner, to circulate within the furnace. Therefore, the temperature at the furnace floor becomes extremely high and an article in the furnace can be uniformly heated.

In FIG. 7 and 8 is shown a heating furnace comprising in combination high velocity gas burners according to the invention and low velocity gas burners. In these Figures, reference numeral 17 designates the low velocity gas burners mounted in the bottom portions of the furnace walls, and having checkers 18 provided forwardly of said low velocity gas burners and defining the end of a combustion chamber 19 for the low velocity gas burners 17 having upwardly opening ports 19a. The high velocity gas burners a7 are mounted above the low velocity gas burners 17. High velocity gas burners a7 designed for jetting the combustion gases at right angles to the center line of the burner and for jetting the combustion gases in the axial direction of the burner can be used in the combination as shown. However, the specific arrangement of these gas burners illustrated is provided by way of example and may be changed according to the construction of the particular furnace. Reference numeral 20 designates exhaust openings.

When the low velocity gas burners start to burn the fuel gas, the resulting combustion gases partially pass through the checkers 18 towards the center of the furnace and partially flow upwards through ports 19a into the furnace, as shown. The high temperature, high velocity hot gas streams jetting from the high velocity gas burners a7, circulate in the upper portion of the furnace. Therefore, the ascending combustion gases from the low velocity gas burners 17 are stirred by the circulating hot gas streams. Such stirring action brings about the remarkable advantage that the temperatures of the ascending combustion gases and the high velocity hot
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gas streams are uniformized and an excellent temperature distribution is produced within the furnace. In this case, by varying the quantity of the fuel gas fed into the high velocity gas burners, and keeping the quantity of air supplied fixed, the internal temperature of the furnace can be closely controlled and the thermal efficiency can be markedly enhanced.

What is claimed is:

1. A heating furnace comprising a furnace chamber, a plurality of high velocity gas burners mounted in the walls of said furnace chamber, each high velocity gas burner comprising a combustion chamber, a tapered outlet nozzle formed at one end of said combustion chamber and having a cross-sectional area smaller than that of the combustion chamber, said chamber having an air inlet, an air flow equalizing plate having a number of air passage holes therein and disposed within said combustion chamber adjacent said air inlet and a fuel inlet means extending into said chamber adjacent said air inlet and said air flow equalizing plate and curved portions formed on the inner surface of the furnace walls at locations opposite to the outlet nozzles of the respective gas burners for diverting the flow of the hot gas streams jetting from said gas burners.

2. A heating furnace as claimed in claim 1, wherein the gas burners are directed to jet hot gas streams along the furnace walls and said curved portions are formed on the inner surfaces of the furnace walls forwardly of the respective high velocity gas burners in the combustion gas jetting direction.

3. A heating furnace as claimed in claim 1, wherein said gas burners and said curved portions are grouped along the length of said furnace for forming a plurality of successive heating zones in the heating furnace by curtains of hot gases which are formed by the jetting hot gas streams deflected by said curved portions.

4. A heating furnace as claimed in claim 1, wherein the bottom of the furnace is comprised of the bed of a car having grooves thereacross, and the high velocity gas burners are positioned to direct the hot gas streams jetting from said gas burners through the grooves in the bed of the car.

5. A heating furnace as claimed in claim 1, further comprising low velocity gas burners mounted in the lower portion of the furnace, the high velocity gas burners being mounted in the upper portion of the furnace, the combustion gases discharged from the low velocity gas burners ascending in the furnace and being stirred by the hot gas streams jetting from said high velocity gas burners.

6. A heating furnace comprising a furnace chamber, a plurality of high velocity gas burners mounted in the walls of said furnace chamber, each high velocity gas burner comprising a combustion chamber, a tapered outlet nozzle formed at one end of said combustion chamber and having a cross-sectional area smaller than that of the combustion chamber, said chamber having an air inlet, an air flow equalizing plate having a number of air passage holes therein and disposed within said combustion chamber adjacent said air inlet and a fuel inlet means extending into said chamber adjacent said air inlet and said air flow equalizing plate, said furnace having a bottom comprised of the bed of a car having grooves thereacross, and the high velocity gas burners are positioned to direct the hot gas streams jetting from said gas burners through the grooves in the bed of the car.

7. A heating furnace comprising a furnace chamber, a plurality of high velocity gas burners mounted in the walls of said furnace chamber, each high velocity gas burner comprising a combustion chamber, a tapered outlet nozzle formed at one end of said combustion chamber and having a cross-sectional area smaller than that of the combustion chamber, said chamber having an air inlet, an air flow equalizing plate having a number of air passage holes therein and disposed within said combustion chamber adjacent said air inlet and a fuel inlet means extending into said chamber adjacent said air inlet and said air flow equalizing plate, said furnace further comprising a plurality of low velocity gas burners mounted in the lower portion of the furnace, the high velocity gas burners being mounted in the upper portion of the furnace, the combustion gases discharged from the low velocity gas burners ascending in the furnace and being stirred by the hot gas streams jetting from said high velocity gas burners.