GAS BURNING SYSTEM ARRANGEMENT

Donald J. Frey, Hazardville, and Rudolph F. Roerden, Bloomfield, Conn., assignors to Combustion Engineering, Inc., Windsor, Conn., a corporation of Delaware

Filed Apr. 25, 1968, Ser. No. 724,007

Int. Cl. F23n 1/02

U.S. Cl. 431—12 12 Claims

ABSTRACT OF THE DISCLOSURE

An arrangement for increasing the turndown capabilities of a fuel gas burning system, having primary and secondary combustion supporting air chambers, by dividing the gas flow to the burner means into two independent flow streams, the independent flow streams being located so that one flow stream is directed into the primary combustion supporting air chamber and the other gas flow stream is directed into the secondary combustion supporting air chamber. A common control means, responsive to changes in load, is provided to modulate the secondary air flow stream and its associated gas flow stream so that at decreasing loads, increasing proportional amounts of total air and gas are admitted through the primary burner portion.

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to gas burning systems and more particularly to a method and apparatus for increasing the turndown capability of a fuel gas burning system.

In the modern versatile heat generating apparatus utilizing gas or gas-and-oil burners, the operating range over which the burner must efficiently function is usually quite large. Heat generating apparatus for industrial boilers may require a burner to operate in a load range of 10 to 1; that is, the burner should be capable of efficient operation at 1/10 its maximum capacity (firing rate).

The basis for this range variation is that industrial boilers must be able to maintain a minimum firing of 10% under certain conditions, such as start-up, in order to protect the tubing therein.

Burner range is dependent upon the efficiency of the mixing of combustion supporting air and fuel gas. As an illustrative example, practice has shown that in a typical application a 1/4 p.s.i.g. minimum gas pressure requires a 25 p.s.i.g. maximum gas pressure at full load to achieve adequate mixing to accomplish the desired 10 to 1 burner load range capability. However, the demand for industrial equipment operative with a maximum fuel gas pressure of 2 p.s.i.g. or less while maintaining the wide turndown capabilities is ever increasing. Therefore it is obvious that a burner arrangement is needed capable of providing superior mixing characteristics at minimum fuel pressures and it is to that end to which our arrangement is directed.

Minimum fuel gas pressure required for protection during adverse firing conditions is dependent on such varied factors as burner size, maximum available gas pressure supply, and the type of control system employed. In the final analysis, however, the minimum gas pressure which may be used is the minimum pressure sufficient to promote adequate mixing of the gas with combustion supporting air.

To accomplish adequate mixing, a properly designed burner will direct combustion supporting air as close as is possible to the fuel gas supply nozzle. Additionally a rotational mode may be imparted to the air to increase the turbulence thereof to further improve mixing. The more successful the design in accomplishing the above, the less the dependence on gas velocity to accomplish the necessary fuel and air mixing. In the past a concentric sleeve of a somewhat smaller diameter than the overall burner diameter has been used to direct an increasing portion of combustion supporting air to the vicinity of the centrally located gas nozzle. Due to its rotational component, however, the air tends to hug to the outer boundaries of the concentric sleeve of the burner. Therefore, there must still exist substantial gas momentum to accomplish adequate mixing.

In view of the above problems associated with previously available burners we have devised a burner system arrangement with sufficiently thorough air-gas mixing characteristics to provide the wide operating range with the low gas pressures desired in today's modern heat generating units. Adequate combustion air-gas mixing for a wide turndown range is accomplished in this novel burner system arrangement by a division of the fuel gas into two distinct flow channels which are proportioned to their respective quantities of combustion supporting air over the full operating demand load range of the burner, one gas flow stream being admitted into its respective combustion supporting air stream at the point of highest air velocity. Turndown control is affected by modulation of the other gas flow stream and its related combustion supporting air flow stream so that the ratio of combustion supporting air and gas in the second stream to total required combustion supporting air and gas increases with increasing load.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a view, partly in cross section and partly schematic, of the burner system arrangement of the present invention.

FIGURE 2 is a front view of the burner throat portion of the burning system as viewed in the direction of arrows 2—2 in FIGURE 1.

FIGURE 3 is a graphical representation of the relationship of combustion gas and combustion supporting air flow streams for the burner system of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGURES 1 and 2, numeral 10 designates generally the novel burner system arrangement of our invention. Windbox 12, attached to furnace wall 14, has a combustion supporting air supply passage 16 at the lower portion thereof. Adjacent windbox 12 in the furnace wall 14 is a port 18 in which the burner tile throat 20 is mounted.

Mounted within windbox 12 is a burner means 22. The burner means 22 comprises a primary air sleeve formed by concentric cylindrical rings 24 and 26 connected together by a nozzle forming means 28 having plural inwardly and outwardly directed nozzle apertures 29 and 29' (see FIG. 2) thereof. Within concentric cylindrical rings 24 and 26 is an intermediate cylindrical concentric ring 30 which divides the burner means 22 into distinct concentric fuel chambers 32 and 34. Connected to chamber 32 is a gas feed line 36 which a second gas feed line 38 is connected to chamber 34 for the purposes to be discussed hereinafter.

Mounted in the windbox 12 through the burner means 22 is a standard ignitor means 40 for fuel ignition. Within the burner means 22 are rotary vanes 46 to impart a rotational spin to the primary combustion supporting air as further described hereinafter. Adjacent the burner means 22 through the rear wall of the windbox 12 is mounted a view port 48 for optically observing the burner flame. Optionally mounted within the burner is an oil gun 42, for supplemental firing, mounted within...
an oil gun guide sleeve 44. The selective addition of oil firing forms no part of the present invention and therefore will not be further considered. Wall 50 in the combustion supporting air supply passage 16 divides the combustion supporting air supply means within windbox 12 into a primary air supply chamber 52 and a secondary air supply chamber 54. Chamber 52 connects with the primary burner chamber 56 within the windbox air sleeve (24, 26), while secondary air chamber 54, through rotary vanes 58, connects with the secondary burner chamber 60 surrounding the primary air sleeve.

Within the secondary combustion supporting air supply chamber 54 are located damper means 62 controlled by linkage means 68 from the drive unit 76 for regulating the flow of secondary air. Drive unit 76, as is further described hereinbelow, is controlled by a differential pressure controller 78 receiving pressure signals from pressure taps 80 and 82 located within the combustion supporting air supply passage 16 and within the furnace respectively. Drive unit 76 also controls valve 74 located in the gas line 38 for regulating the flow therein.

During operation of our burner system arrangement, combustion supporting air is supplied through combustion supporting air supply passage 16 to the primary combustion air supply chamber 52 and the secondary combustion air supply chamber 54. The primary combustion supporting air passes from chamber 52 through the primary burner chamber 56 being rotated by vanes 46 and attaining maximum velocity as it passes the inwardly directed nozzle apertures 29. Secondary combustion supporting air passes from chamber 54 through rotational vanes 58 into secondary burner chamber 60 and then outwardly directed nozzle apertures 29. Burner means 22 is supplied with fuel gas by means of main gas line 70. Flow in line 70, controlled by valve 72, connects to a primary gas supply line 36 and a secondary gas supply line 38. The secondary gas fuel flow in line 38 is regulated by valve 74 as noted above.

The operational control for wide range turndown capabilities of our novel burner system arrangement comprises a regulation of the proportion of the secondary fuel gas flow and secondary combustion supporting air flow, and the total fuel gas flow and total fuel gas requirements for burner operation. This relationship is depicted graphically in FIGURE 3. The plot of FIGURE 3 shows the percent of combustion supporting air and fuel required for any particular percent of boiler rating. Solid line 84 and dashed line 86 represent the total fuel gas requirements for burner operation. Solid line 88 and dashed line 90 respectively represent the primary air flow and primary fuel flow as a proportion of the total air and fuel requirements. As can readily be seen, at low loads, the total air and total fuel requirements are obtained solely from primary air and primary fuel streams while over a substantial portion of the remainder of the burner load the amount of primary air and primary fuel remain constant. Solid line 92 and dashed line 94 represent the secondary air flow and secondary fuel flow as a proportion of the total air and total fuel requirements. The percentage of secondary air and secondary fuel to the total requirements is zero until approximately 30% of the boiler rating (or burner load demand). The proportion of secondary air and secondary fuel to the total requirements is modulated over the remainder of the burner load in substantially linear proportion to the increasing air fuel requirements so that the percentage of secondary air and secondary fuel increases with the increasing total air and fuel requirement.

The control of the secondary combustion air and secondary fuel gas is accomplished as follows. Fuel gas in main gas line 70 is regulated to an initial pressure by valve 72. Valve 74 in secondary gas line 38 is closed so that the total fuel gas supply passes through gas line 36 into the primary fuel chamber 32 and thence into the primary burner region through inwardly facing nozzle apertures 29. The dampers 62 in the secondary air supply chamber 54 are closed so that the total inwardly facing nozzle apertures 29 pass the inwardly facing nozzle apertures 29 so as to admit the primary fuel and primary combustion air (at the point of maximum air velocity). Upon ignition by the standard ignitor 40, a burner flame will be initiated.

Pressure taps 80 and 82, located as noted above, detect the pressure differential across the burner apparatus. A change in this differential pressure from the selected "set point" pressure caused by varying load demands (detected as an increase or decrease in windbox pressure) will generate a signal in the differential pressure controller 78 to operate drive unit 76 to control, through linkage means 68, the position of valve 74 in the secondary gas line 38 and dampers 62 in the secondary combustion air chamber 54. The regulation of valve 74 and dampers 62 controls the proportion of secondary air and secondary fuel to the burner system arrangement with respect to the total fuel requirements thereof according to the relationships as discussed above and shown in the graph of FIGURE 3. That is, upon a change in load demand, valve 74 will admit the necessary additional amount of secondary air and the specific portion of fuel gas supply to pass through gas line 38 into the secondary fuel chamber 34, and thence into the secondary burner region through outwardly facing nozzle apertures 29 to be mixed with a specific portion of the combustion supporting air passing into the secondary combustion air supply chamber 34 through vanes 58 and into the secondary burner chamber 60.

Thus it can be seen that our novel burner system arrangement is capable of efficient operation over a wide load range with a very small required gas supply pressure. This is accomplished by an air admixing, at low burner demand loads, of primary combustion supporting air with primary gas adjacent the primary air sleeve where the primary gas nozzle apertures are located and where air velocity is maximum. As the load demand on the burner increases, a control means functions to bring in required additional air by secondary burner porting to rect an increasing proportion of the total air and total fuel gas requirements to the secondary air and secondary fuel portions of the burner. A stable flame is thus created through the entire range of burner operation with only the barest of minimum gas pressures necessary for adequate air-gas mixing.

While we have illustrated and described a preferred embodiment of our invention, it is to be understood that such is merely illustrative and not restrictive and that variations and modifications may be made wherein without departing from the spirit and scope of the invention. We therefore do not wish to be limited to the precise details set forth but desire to avail ourselves of such changes as fall within the purview of our invention.

We claim:

1. An apparatus for increasing the turndown capabilities of a gas burning system comprising: a furnace wall having an opening therein, a windbox associated with said opening, means in said windbox for supplying combustion supporting air through said windbox into said furnace through said furnace wall opening, first dividing means for dividing the combustion supporting air flow into a proportion to the incremental secondary air stream, a burner means in said windbox adjacent said furnace wall opening for generating a flame, fuel gas supply means for transporting fuel gas to said burner means, said burner means having second dividing means for dividing said fuel gas into a primary gas stream and a secondary gas stream, said second dividing means operative to admit the primary gas stream with said primary air stream while admixing said secondary gas stream with said...
secondary air stream, and modulating means responsive to varying furnace load conditions to regulate the flow of the secondary air stream and the secondary gas stream for controlling the burner flame.

2. The apparatus of claim 1 wherein said first dividing means includes first conduit means directing the flow of said primary air stream substantially centrally of said furnace wall opening, and second conduit means directing the flow of said secondary air stream annularly about said primary air stream flow.

3. The apparatus of claim 2 wherein said first and second conduit means each have vane assemblies therein for imparting a rotational spin to said primary and secondary air stream flows therethrough.

4. The apparatus of claim 1 wherein said modulating means comprise damping means in said secondary air stream, valve means in said secondary gas stream and a control means for regulating the degree of opening of said damping means and valve means such that the proportion of secondary combustion supporting air and secondary gas of the total required combustion supporting air and total fuel gas increases as burner load demand increases.

5. A gas burner system comprising an air sleeve means having inner and outer substantially cylindrical surfaces with a space therebetween, first and second combustion supporting air supply means supplying independent combustion supporting air streams to said burner system, first and second fuel gas supply means supplying independent fuel gas streams to said burner system, means within said air sleeve surfaces connected to said first and second combustion supporting air supply means for admixing said first gas stream with said first air stream and for admixing said second gas stream with said second air stream and means for varying the flow of said second gas stream and said second air stream in relation to burner load.

6. The apparatus of claim 5 wherein said varying means includes control means to regulate the flow of said second gas stream and said second air stream so that the proportion of said second fuel gas stream and said second air stream to the total required fuel gas and total required combustion supporting air is small at low burner loads and increases as the burner load increases.

7. The apparatus of claim 6 wherein said control means for regulating said proportion of said second gas stream and said second air stream to total required fuel gas and combustion supporting air comprise a damping means in said second air stream, valve means in said second gas stream, and a common drive unit for controlling both said damping means and said valve means, said drive unit actuated by an operator means, said operator means seeking to maintain a constant pressure differential across said burner system through at least a major portion of the burner load range.

8. The apparatus of claim 5 wherein said means for admixing said first fuel gas stream and said first air stream comprise a passageway within said inner and outer surfaces of said air sleeve, said passageway having at least one nozzle-like opening directed into the flow of said first air stream, and wherein said means for admixing said second fuel gas stream and said second air stream comprise a passageway within said inner and outer surfaces of said air sleeve adjacent said first mentioned passageway, said second mentioned passageway having at least one nozzle-like opening directed into the flow of said second flow stream.

9. The apparatus of claim 8 wherein said first combustion supporting air supply means directs said first air stream in a rotary manner through the inner surface of said air sleeve, and said second combustion supporting air supply means directs said second air stream in a rotary manner about the outer surface of said air sleeve.

10. A method of improved operation for a gas burner system having independent primary and secondary fuel gas streams and independent primary and secondary combustion supporting air streams, comprising the steps of: admixing the primary fuel gas stream with the primary combustion supporting air stream, admixing the secondary fuel gas stream with the secondary combustion supporting air stream, modulating the secondary fuel gas stream flow and the secondary combustion supporting air stream flow over the burner load range so that the proportion of secondary gas and secondary air to the total required fuel gas and total required combustion supporting air is small at low burner loads and increases as the burner load increases.

11. The method of claim 10 wherein the steps of admixing said primary gas stream and said primary combustion supporting air stream is caused to occur at the point at which the velocity of the combustion supporting air is highest.

12. The method of claim 10 wherein the step of modulating the flow of the secondary gas stream and secondary combustion supporting air stream includes the steps of sensing the standard differential pressure across the burner system, sensing a change in said differential pressure across said burner system indicating a change in burner load demand, adjusting said flow of the secondary gas stream and secondary combustion supporting air stream in accordance with the magnitude and direction of the sensed change in differential pressure with respect to said standard differential pressure to restore said standard differential pressure across said burner.

References Cited

UNITED STATES PATENTS

2,480,547 8/1949 Caracristi .......... 431—188
2,531,316 11/1950 Zink .......... 431—188 XR
3,109,481 11/1963 Yahnke .......... 431—284 XR
3,164,209 1/1965 Reed .......... 431—284
3,284,008 11/1966 Miller .......... 431—19 XR
3,294,146 12/1966 Voorheis .......... 431—19

FREDERICK L. MATTESON, Jr., Primary Examiner
R. A. DUA, Assistant Examiner

U.S. Cl. X.R.

431—19, 188, 284