FORCED DRAFT PRIMARY AND SECONDARY AIR FEEDING SYSTEM FOR FURNACES WITH AIR PREHEATING AND TEMPERING MEANS

Charles L. Marquez, Jr., Jersey City, N. J., assignor to 3M Company, New York, N. Y., a corporation of New Jersey

Application August 14, 1948, Serial No. 44,298

6 Claims. (Cl. 110—86)

This invention relates to fuel combustion systems and more particularly to a preheated air supply system for fuel pulverizers and their directly associated fuel burners.

In direct firing pulverizer and burner systems supplied with raw fuel of variable moisture content, a regulation of the supply of heated primary or carrier air to the pulverizer is desirable for the purpose of effecting drying of the coal within the mill to insure most efficient and rapid reduction of the pulverizing apparatus. The temperature of the air is regulated in accordance with resultant temperature in the mill so that the fuel, particularly in the case of coal, is not heated to a temperature at which coking or other difficulties occur in the pulverizer, connecting piping or burners.

Where the primary or carrier air furnishes a portion of the total air requirements, the remainder, commonly known as secondary air, is supplied directly to the burner for mixing thereby with the primary air and fuel stream. The secondary air stream is customarily preheated in an air heater by heat exchange from the stack gases from the furnace and, in the attainment of high overall thermal efficiency, the temperature of the air is frequently higher than that which can be satisfactorily utilized in the pulverizer and related coal conveying portions of the burner apparatus.

It has accordingly been the practice to provide a source of air at lower temperatures, such as room temperature, and to introduce air from this supply into the primary air stream entering the pulverizer. Such lower temperature air is generally called tempering air, and may be supplied from a forced draft air fan called the tempering air fan.

The operation at partial load of a high efficiency air heater presents many practical problems. At partial loads, the overall heater temperature and the temperature of the flue gas are reduced to such an extent, by the passage of cold air therethrough, that condensation of surplus temperature at the cold air inlet becomes a considerable problem.

To overcome these difficulties, it has been proposed to bypass a large portion of the cold air from the forced draft fan around the heater and into the secondary air duct. Another solution has been to recirculate some of the heated air to the cold air inlet to raise the temperature of the incoming air. The present invention makes use of the tempering air fan not only to provide lower temperature air for mixing with the primary air at high furnace temperature but also to supply at least a part of the secondary air at low load factor. The tempering air fan is increased in capacity beyond that normally required, and a short, damper-controlled conduit or passage is provided between the tempering air duct and the secondary air duct adjacent the burner wind box. Conduits or passages are also provided connecting the tempering air duct and the inlets of the primary air fans.

This arrangement is efficacious both at full load and at partial loads. At full load, the temperature of the flue gases passing through the air heater is high. Consequently, the temperature of the air supply drawn through the heater is also high, and may be considerably above its optimum temperature for the primary air entering the pulverizer. Accordingly, the connection between the tempering air duct and the primary air fan is partly or partially open, so that the relatively cooler tempering air at the high temperature of the primary air is used to reduce the temperature of the air entering the pulverizer. At partial loads, the conditions are radically different.

The volume and temperature of the flue gases are greatly reduced, thus reducing the heating temperature of the air heater. As the cold air is drawn through the heater, the resultant cooling effect on the heater may cause condensation of the stack gases and corrosion of the heater elements, particularly at the cold air inlet. With the present arrangement, these undesirable effects are avoided. The large volume capacity of the tempering air fan is used to supply a large part of the required secondary and primary air, thus greatly reducing the air flow through the heater. Consequently, the heater elements can be maintained at a high enough temperature to avoid condensation and resultant corrosion by the condensed flue gases.

It is accordingly among the objects of this invention to provide an improved air supply for a pulverized fuel burning furnace for a fluid heater. Another object is to provide a tempering air supply arranged to furnish a portion of the secondary and primary air requirements of a pulverized fuel fired fluid heater.

A still further object is to provide, in a pulverized fuel fired fluid heater, a tempering air source arranged to provide part of the primary air requirements at high ratings and a substantial part of the primary and secondary air requirements at lower ratings.

These, and other objects, advantages and novel features of the invention will be apparent from the following description and the accompanying drawings:

Fig. 1 is a schematic view diagrammatically illustrating a combustion air supply arrangement according to the invention.

Fig. 2 is a side elevation view, partly in section, of the fluid heater of Fig. 1.

Fig. 3 is a front elevation view of the air supply conduits and primary air forced draft fans for the fluid heater of Fig. 1.

Fig. 4 is a partial side elevation view, partly in section, of the air supply conduits and the primary and tempering air fans.

The principles of this invention are applicable to the preheated air supply system of any pulverized fuel fired furnace for a fluid heater. For illustrative purposes only, however, the invention will be described as applied to a vapor generator as shown schematically in Fig. 1 and structurally in Figs. 2 to 4.

Referring to Fig. 1, a furnace 10 is diagrammatically shown as having a plurality of pulverized fuel burners 11 mounted in its front wall 12. As shown by way of example, there are nine burners arranged in three groups, each group comprising three burners. The three burners 11 of each group are each supplied with fuel from one of three fuel pulverizers 15 connected to lines 13, 14 and 16, respectively. The left hand pulverizer 15 has three lines 13 respectively connected to the left hand burner of each group, the center pulverizer 15 has three lines 14 respectively connected to the central burner of each group, and fuel lines 16 connect the right hand pulverizer to the right hand burners of the three groups.

A primary air fan 65 is provided for forcing air into each pulverizer, and the resultant air streams entrain particles of pulverized fuel and carry them through lines 13, 14 and 16 to burners 11. The arrangement is such that either one, two or three pulverizers may be used to supply fuel to the furnace, dependent upon the fuel requirements of the furnace. The fuel fed to burners 11 is burned in furnace 10 and the resulting gaseous products of combustion, or flue gases, are directed through the hot gas inlet 41 and through the heat exchange tubes 42, of an air heater 40, located at the rear of the furnace.

Cold air, from a variable delivery forced draft fan, enters air heater 40 through cold air inlet 43 and is heated by passing over and between the heat exchange tubes 42. The heated air passes from heater 40 into secondary air ducts 50 connected to either end of a duct section 55 adjacent front wall 12 of furnace 10. Duct section 55 is in extensive communication with wind box 56, which supplies preheated secondary air to the furnace burners 11. The primary combustion air for the burners is supplied, of course, by the air streams carrying fuel particles from pulverizers 15.
A primary air duct 60 extends along wall 12, being substantially coextensive with secondary air duct section 55. Duct 60 is in communication with section 55 through a relatively large cross passage 61 so that heated air from heater 40 enters duct 60 freely from section 55 through passage 61. Conduits 62 connect duct 60 to the inlets of the three primary air fans 65.

In accordance with the invention, a relatively short tempering air duct 70 extends parallel to primary air duct 60 and secondary air duct section 55, being supplied with air at room or ambient temperature through the medium of a tempering fan 75 delivering to one end of duct 70 while the duct is at a temperature with the pressure in wind box 56. The opposite end of duct 70 may be closed. In the present invention, fan 75 has a capacity considerably in excess of that required only for tempering air. A relatively large cross passage 73 connects duct 70 to each conduit 62, and proportioning dampers 72 are arranged at the intersection of each conduit 71 with a conduit 62. A relatively large cross passage 73 connects tempering air duct 70 to secondary air duct section 55, and is controlled by a damper 74.

The described arrangement operates in the following manner: The air forced into pulverizers 15 by fans 65 entrains fuel particles which are carried through lines 13, 14, 16, to burners 11. The fuel burns in furnace 10 and the resultant gas flows through heater 40 to heat and pass through a passage 73. At full load, the temperature and volume of the flue gases are such that the air delivery from the heater is at maximum temperature. Consequently, the secondary air duct 60 is not used, resulting in the air delivered to the primary air duct 60 being at a corresponding temperature. If this hot primary air entered pulverizers 15 through conduits 62, it would normally be at too high a temperature for satisfactory operation of the pulverizers and burners. To reduce the temperature of the air entering the pulverizers under these conditions, dampers 72 are so positioned that relatively cool tempering air from duct 70 is mixed with the hot air from duct 66. The proportioning is preferably such that the temperature of the air and fuel enters furnace 15 fan box 11, at which the air and fuel conduits 71 and 14, 16 lead to burners 11, is at or below a predetermined maximum.

At materially reduced loads, the temperature and volume of the flue gases are such that, if a proportional volume of cold air is drawn through heater 40, condensation of flue gases and corrosion might occur. Under these conditions, section 75 is opened so that air from fan 73 is delivered from duct 70 to duct section 55 through cross passage 73, supplying a large part of the secondary air requirements. Consequently, the volume of air drawn through the heater is greatly reduced, thus decreasing the likelihood of condensation and corrosion at the cold air inlet. It will be noted that the constantly operating fan 75 serves a dual purpose in that it not only provides the maximum required amount of tempering air for the primary air streams at maximum load conditions when the air delivered from the preheater is at maximum temperature, but it also serves to supply secondary air to the secondary air supply conduits 85 at reduced loads when the requirement of tempering air is usually correspondingly reduced because of the lower temperature of the air delivered from the air heater.

While fan 75 may be operated at either constant or variable volume delivery, the proportion of the secondary air requirements which may supply can be increased materially at lower loads, so that the remaining secondary air flow over the inlet tubes of the air heater is thereby reduced, with consequent reduced cooling of such tubes and moisture condensation from the flue gases. Figs. 2 through 4 illustrate an actual vapor generator installation embodying the invention. Referring to these figures, furnace 10 is shown as having its walls constructed by a wall 17, and the floor 18. A vapor generator 20 is mounted in the furnace in the path of the hot gas flow, and includes a liquid drum 21 and a vapor drum 22 connected by tubes 23 to a superheater 25 in the path of the hot gas flow. The vapor flowing through superheater 25 may pass through an attemperator 26 connected intermediate sections of the superheater. Superheated vapor is withdrawn through pipe 27.

It will be noted that the hot combustion gases flow generally upwardly and rearwardly in a first pass in which they contact vapor generator 20 and superheater 25. This first pass is defined by wall 24 and sloping wall 26. As an example of furnace 10, when passing superheater 25, the hot gases are deflected downwardly through a second, or economizer, pass defined by vertical liquid tube walls 31, 32 forming part of an economizer heating drum 33 and interconnected by other tubes 34. Liquid enters the economizer from feed pipe 37 and is withdrawn through pipe 38. Baffles 39 assure thorough circulation of the combustion gases in the economizer.

From the bottom of the economizer pass, the gases flow into air heater 40 having a hopper bottom 44, where they pass through pipes 42 into a conduit 46 for conveying the temperature air leading to the stack. A forced draft fan (not shown) forces incoming air into the cold air inlet 43 adjacent the top of heater 40, and the air passes downwardly through the heater and into the secondary air ducts 50 extending downwardly and then around each side of the furnace to the ends of front section 55.

The secondary air duct is generally rectangular in cross section, and its front section 55 opens upwardly into wind box 56 through which extend the fuel lines 13, 14, 16 connected to the sets of burners 11. Section 55 has an intermediate extending a considerable length 57. The section 55 extends outwardly from the central portion of section 55 and connects to duct 60. The latter is a rectangular duct smaller in size than duct 50 and extends parallel to section 62 extend downwardly and inwardly from primary air duct 60, and connect to the inlets of primary air fans 65 which are located beneath secondary air duct 50. Conduits 63 connect the fan outlets to the three unformly spaced pulverizers 15. Dampers 72 are pivotally connected in the vertical sections of conduits 62 at the intersection of the latter with horizontal conduits 71 connecting the air heater duct 70. The dampers 72 are so arranged as to wholly or partially close or open either conduit 62 or 71, so that the air to the inlets of fans 65 may be drawn, as desired, from either or both of ducts 60 and 70.

The tempering air fan 75, of higher capacity than normally used for tempering air, is located beneath one of the side runs 51 of conduit 85, and its outlet is connected by a vertical run 76 to one end of tempering air duct 70. The latter is a rectangular duct extending beneath duct 50 and alongside duct 60, and is substantially coextensive with section 55 of duct 50. Three horizontal conduits 71 connect duct 70 to conduits 62, as described, with the left hand conduit 71 closing the far end of duct 70. Adjacent the midsection of duct 71 was a vertical conduit 73 through cross passage 73, rectangular in section, connects duct 70 to secondary air duct section 55. Passage 73 is controlled by a damper 74 mounted in the lower horizon of the passage. The partition 57 prevents direct flow of tempering air into cross passage 61 when damper 74 is open.

The described embodiment operates in the same manner as that of Fig. 1, which is actually a diagrammatic showing of the practical construction of Figs. 2 through 5. The higher capacity tempering air fan 75 has the dual function of providing tempering air for pulverizers 45 at full-load and a portion of the secondary and primary air at partial loads.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the principles thereof, it should be understood that the invention may be embodied otherwise without departing from such principles.

I claim:

1. In a combustion system, a furnace; variable capacity burner means incorporated with the furnace; an air heater connected to the hot gas outlet of said furnace; a fan for air supply to the hot gas flow; and a pass through the air heater in heating relationship to air supplied to said air heater; variable delivery means supplying air to said air heater; a secondary air duct for supplying high temperature secondary air from said burner means; a primary air duct; a connection between said secondary and primary air ducts for supplying hot air from said heater to said primary air duct; a tempering air means for supplying lower temperature air to said secondary air duct; and a conduit means connected to said burner means; control means operatively associated with said
conduit means, said primary air duct and said tempering air duct for connecting said conduit means to either or both said primary air duct or said tempering air duct; passage means interconnecting said secondary air duct and said tempering air duct for delivering air from said tempering air duct to said secondary air duct; and selectively operable means operatively associated with such passage means controlling air flow therethrough to control the relative amounts of air supplied to said secondary air duct by said variable delivery means, through said air heater, and from said tempering air duct.

5. In a combustion system, a furnace; variable capacity burner means incorporated with the furnace; a pulverizer for supplying fuel to said burner means; an air heater connecting said hot gas outlet of said furnace for flow of the combustion gases from the furnace through the air heater in heating relationship to air supplied to said air heater; variable delivery first draft means supplying air to said heater; a secondary air duct for supplying high temperature secondary air from said heater to said burner means; a primary air duct substantially coextensive with said section; a section between said section and said primary air duct for supplying hot air from said heater to said primary air duct; a tempering air duct substantially coextensive with said primary air duct; means for supplying lower temperature air to said tempering air duct; conduit means connected to said burner means; control means operatively associated with said conduit means, said primary air duct, and said tempering air duct for connecting said conduit means to either or both said primary air duct or said tempering air duct; passage means interconnecting said secondary air duct and said tempering air duct for delivering air from said tempering air duct to said secondary air duct section; and selectively operable means operatively associated with such passage means controlling air flow therethrough to control the relative amounts of air supplied to said secondary air duct by said variable delivery means, through said air heater, and from said tempering air duct.

6. In a combustion system, a furnace; variable capacity burner means incorporated with the front wall of said furnace; a pulverizer for supplying fuel to said burner means; an air heater connecting said hot gas outlet of said furnace for flow of the combustion gases from the furnace through the air heater in heating relationship to air supplied to said air heater; variable delivery second draft means supplying air to said heater; a secondary air duct for supplying high temperature secondary air from said heater to said burner means; a primary air duct substantially coextensive with said section; a section between said section and said primary air duct for supplying hot air from said heater to said primary air duct; a tempering air duct substantially coextensive with said primary air duct; means for supplying lower temperature air to said tempering air duct; conduit means connected to said burner means; control means operatively associated with said conduit means, said primary air duct, and said tempering air duct for connecting said conduit means to either or both said primary air duct or said tempering air duct; passage means interconnecting said secondary air duct and said tempering air duct for delivering air from said tempering air duct to said secondary air duct section; and selectively operable means operatively associated with such passage means controlling air flow therethrough to control the relative amounts of air supplied to said secondary air duct by said variable delivery means, through said air heater, and from said tempering air duct.
through said air water and by said second forced draft fan.

References Cited in the file of this patent

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,863,541</td>
<td>Locke</td>
<td>June 14, 1932</td>
</tr>
<tr>
<td>2,230,799</td>
<td>Hobbs</td>
<td>Feb. 4, 1941</td>
</tr>
<tr>
<td>2,321,129</td>
<td>Cooper</td>
<td>June 8, 1943</td>
</tr>
</tbody>
</table>

FOREIGN PATENTS

<table>
<thead>
<tr>
<th>Country</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great Britain</td>
<td>Dec. 20, 1928</td>
</tr>
<tr>
<td>Germany</td>
<td>July 30, 1931</td>
</tr>
<tr>
<td>Great Britain</td>
<td>June 8, 1933</td>
</tr>
</tbody>
</table>