BLAST AIR HEATING STOVE IN METALLURGICAL FURNACES AND THE LIKE

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ABSTRACT OF THE DISCLOSURE

A blast air heating stove is provided with a combustion chamber at the top of the stove which is of a conical configuration and includes a slide valve which determines the degree of mixing of the fuel and air within the combustion chamber, such mixing determining the rate of flame propagation and flame length. The blast air heating stove does not require preheat of air or gas for attaining the proper flame speed, flame propagation, and so forth.

This invention relates to an improved blast air heating stove for metallurgical furnaces and the like, and to a combination of such a stove with a burner and combustion chamber which is capable of more efficiently heating air which is passed through the stove in conjunction with metal-producing operations.

Current metal-producing operations, and particularly steel-producing operations, have necessitated supplies of preheated air at higher temperatures and in greater amounts. This demand for greater air blast is because of the better prepared and higher iron concentrates now being used as furnace charge stock as compared to the previously used straight ones. This improved charge can tolerate a substantially higher blast rate and so greatly increases the furnace capacity if sufficient blast air is available. In an effort to meet this demand for higher temperatures or greater volumes of heated air the art has turned to increasing the physical size of the heat exchanger. For example, those skilled in the art have attempted to solve the problem by merely adding additional height to the heat exchanger. This expedient produces disappointingly meager results. An increase in height of the heat exchanging tower in spite of the addition of a greater mass of refractory bodies has not yielded proportionately greater blast rate or a proportionately increased temperature which can be used for the steel-making operation.

It is known that the upper or top portion of the ceramic charge provides the greatest heating effect to the air blast. Merely adding height to the heat exchanger raises this portion of the heat exchanger without adding appreciably to the capacity or efficiency of the heat exchanger. What is needed, therefore, is an improved stove in which a larger volume of air can be passed through to meet the increased demand for heated air in steel-producing operations and also, if possible, to produce an increase in temperature as well. The need for this supply of additional sensible heat in substantial amounts is particularly acute where the blast furnace is supplied with various hydrocarbon fuels which are injected through the tuyeres. This is an advantageous method of operation because cheaper injectants permit reduction of high priced coke per ton of metal produced and therefore such hydrocarbon fuel injectants are important from an economy standpoint but it is only possible to use these injectants where there is an adequate supply of high temperature air because the materials are endothermic in their effect on the furnace’s heath temperature.

As less coke is needed in the burden, it can be replaced with iron ore and consequently the steel making capacity of the furnace is increased but this also demands a further air flow. It can be now seen how important the air supply is.

In a distinctly different effort to increase the efficiency of the stove some attempts have been made to provide an external combustion chamber which is located exteriorly of the furnace and having ceramic or other refractory packing in place of the combustion chamber previously located interiorly of the stove.

However, the cost of these outside combustion chambers is quite high and frequently their installation is also confronted with space problems. Also there are maintenance difficulties inherent in them due to differential expansion of the structure connecting the two chambers. Also, there is a tendency for some unevenness of heat distribution because the hot gases have a velocity head which tends to carry the greater mass to the far side of the setting. This same connection area will have refractory problems requiring frequent maintenance and which will increase in relation to the temperatures developed therein.

Other designers are offering combustion system designs that have burners firing from the stove sidewall at a point just over the top of the checker setting. Extreme care must be exercised with this arrangement or some combustion will take place down in the flues to the detriment of the checkers and loss of heat distribution control. To get suitable distribution of heat, multiple burners are required which increase the costs of combustion and maintenance. Such designs can also create stove dome trouble.

What the present invention proposes is to eliminate the vertical combustion chamber within the stove and install additional checkers in its stead. In combination with said greater utilization of internal chamber, I propose to remove the conventional hemispherical steel dome and in its place install a conical top of sufficient height and a proper angle of divergence to produce an ideal burner combustion tunnel. In fact, the entire void above the checkers to the top of the refractory lined cone is made a part of a large burner. On the top of the cone is an especially designed gas/air mixer to give a very rapid and thorough mixing of the two materials which will produce a stable flame retention despite the leanness of the gas even at high input rates. Such rates of burning are not possible in present vertical combustion chambers. The intensity of the flame produced and the input rate would soon scour out the skin wall of the tunnel opposite the burner discharge. This cannot occur in my large and diverging tunnel and consequently input rates can be increased much beyond present ones. This will be reflected in the ability to release more heat and obtain faster recoveries.

Because of the nature of the burner and its diverging combustion zone, the heat of the fully combusted products will give an absolutely uniform distribution as it enters the checkers. Also, due to the nature of the air/fuel mixing mechanism of the burner the control of flame length is such that it can be lengthened or shortened as may be desired.

It is one of the foremost objects of the present invention to provide an improved stove construction which substantially increases the capacity of existing stove structures for producing greater volumes of preheated air which can be raised to higher temperatures. It is a further object of the present invention to provide a novel structure and location of combustion chamber which enables more efficient utilization of the combustion volume available and of the ceramic heat-exchanging packing within the tower of the stove for obtaining a greater supply of high temperature air but without in any way injuring the packing or reducing its useful service life.

It is a further object of the present invention to provide, in combination with a heat exchange tower, a new and improved combustion chamber having a simple burner, a combination mixing and combustion chamber, which is capable of producing high combustion rates and
with a controlled flame propagation so that none of the flame will impinge destructively on the packing of the heat exchanger so as to necessitate premature replacement of the packing.

As a part of the last mentioned object of the invention, there is provided novel regulating means for controlling the rate of burning as well as such parameters as intensity of burning and flame propagation to achieve the optimum generation of heat during the heat-up cycle of the refractory packing, which is then followed by a blast of air which is increased in temperature by sweeping over the previously heated refractory packing.

An important object of the present invention is to produce a stove having a greater quantity of checkerwork by reason of eliminating the vertical heating chamber previously present and thereby adding heat capacity to the stove.

An important feature of the present invention is utilizing an improved heating chamber which provides greater uniformity of heating, higher temperatures, faster recovery and yet is operable with leaner fuels and higher temperatures, all of this being accomplished without sacrifice of service life of the checkers or requiring any added maintenance.

These results are achieved not only by the novel placement of the combustion chamber but also because of its novel configuration, that is, a novel configuration making it possible to control the various parameters of flame propagation, heating rate and nondestructive heating of the refractory packing.

The foregoing and additional objects of the present invention will be apparent from a consideration of the following description which proceeds with reference to the accompanying drawings, wherein:

FIGURE 1 is an elevation view, showing in section the heat exchanger, including the packing and combustion chamber;

FIGURE 2 is a section view taken on line 2-2 of FIGURE 1;

FIGURE 3 is a top view of the structure shown in FIGURE 1, looking in the direction of the arrows 3-3;

FIGURE 4 is a section view taken on line 4-4 of FIGURE 1; and

FIGURE 5 is a graph illustrating, in relative units, the temperature rise of air versus the height of the tower.

Referring now to the drawings, a heat exchanger designated generally by reference numeral 10 includes a tower 12 comprising of a shell 14 having a liner 16 of suitable heat-resistant refractory composition. Within the shell is a packing designated generally by reference numeral 18 and comprised of a plurality of ceramic heat-resistant refractory bodies referred to as checkerwork which are capable of being heated up and storing heat and for thereafter imparting it to a blast of air which is introduced through the heat exchanger. The refractory mass 18 is supported on a plurality of pedestals 20, or the like, which vertically support the mass of refractory checkers which are spaced to provide flow paths for the gaseous combustion products which flow downwardly and the flow of air which passes through the stove in a manner to be described. The pedestals 20 not only support the refractory packing 18 but also define a chamber 22 having an inlet 24 for the updraft of air which is passed vertically upwardly through the mass of heated refractory. This is preheated by an outlet opening 26 for the exhaust products generated in combustion chamber 28 during heat-up of the refractory packing 18.

The chamber 28 surrounds the tower 12 and is preferably of frusto-conical construction, being of brickwork or other suitable heat resistant refractory composition brick or the like. Preferably the burner chamber 28 is frusto-conically constructed and this is the configuration recommended for best results; however, other shapes, such as spherical, are within the scope of the present invention but are not as efficient or as useful as the frusto-conical shape. Within the chamber 28 there is burned a combination of fuel which is injected from a conduit 36, having a control 33. The fuel being blast furnaces or the like, is at the time of being injected, in the proper physical form for burning. The combustion-supporting gas for burning the fuel is in the form of air and such combustion-supporting gases are introduced through an inlet line 32 having a control valve 34. The inlet valve 34 is controlled by an arcuate gate 42 (FIGURE 4). Depending upon the position of the gate 42 there will be introduced a precise, controllable rate and direction of flow of fuel indicated by the arrows 44 and 46. The inflow of fuel tends to follow a swirling, vortexing movement and a sub-pressure zone is created at the central portion 48 of the inlet chamber 50. Such differential pressure action tends to draw the air material into it and creates flow paths indicated by reference numeral 52 (FIGURE 1) within chamber 28. The burning action is highly controllable and unlike other previously used for firing stoves will not cause damage either to the sidewalks of the upper chamber or the checkerwork. The cone shaped burner chamber is configured so that the gases are permitted to expand and completely burn but without such combustion occurring within the checkerwork to cause its damage. The fuel and the air which describes a downwardly spiraling or vortexing path from chamber 50 into chamber 28, produces a turbulence between the two materials, thoroughly mixing them and causing the two to ignite. The ignition is within chamber 28 and the interior walls 53 of the frusto-conically shaped chamber 30 promote such combustion and at a rapid and efficient rate. Flame which is propagated by the combustion is controllable by the gate 42. For example, under high inflow rate and high volume inflow the vacuum which is produced is of a higher degree and the combustibles are drawn vertically higher and burning occurs at a higher level within chamber 28. Conversely, by decreasing the flow rate and decreasing the volume, mixing and combustion occurs at a lower level within chamber 28. By suitably adjusting the position of the gate 42 and by regulating the amount of inflow of combustibles from line 36 it is possible to effect complete and efficient combustion and moreover to regulate the flame propagation within chamber 28 so that none of the generated flame impinges upon the ceramic packing within the tower and for this reason the refractory is not damaged in spite of being exposed to a substantial temperature.

Since the entire cross section of the tower is filled with refractory heat-absorbing media the tower is now more efficient in imparting higher temperatures to a flow of air which is next passed upwardly through the tower from inlet 24 and following completion of the combustion within chamber 28. It was previously the practice to use a portion of the vertical cross section as a combustion chamber and to that extent there was unavailable the heat-absorbing refractory media which was capable of heating the air or other upblast material intended for use in the steel-making operations. Now such area is filled with checkerwork.

With the present invention it is possible to regulate the ratio of fuel to air both by means of controlling the valve 38 and by means of controlling the rate of injection of air from line 32 and, knowing the burning rate and rate of generation of heat, it is possible to regulate the position of the gate 42 to properly position the occurrence of burning within chamber 28 and prevent flame propagation below the level of the burner, which, as previously described, is comprised of a plurality of heat-absorbing ceramic or checkerwork 18.

During the burning cycle within combustion chamber 28 the pellets absorb the heat and the products of combustion are dissipated vertically downwardly leaving the
system through port 26 and are vented to atmosphere through a stack, or the like (not shown). After sufficient heat has been absorbed by the media, the burning operation is terminated and this is followed by an air upblast and the air, as it passes through the heated refractory media which is formed as a packing within the tower, will become heated and elevated in temperature. Since the upper portion of the checkerwork performs the greatest heating function, it is highly advantageous that in the present invention this is the portion which is directly heated by combustion gases and is therefore best capable of imparting higher degrees of heating temperature to the air as it progresses upwardly and becomes successively hotter. Since a greater quantity of heat is stored through the cross section of the stove by reason of its entire cross section being filled with ceramic particles, there is a greater capacity of the stove for heating the air and hence air in greater quantities can be passed through the stove to meet the higher schedule of demand of steel-making facilities. For example, referring to the graph of FIGURE 5, it will be seen that where efforts are made to increase the capacity of a stove by merely increasing the height, the air will tend to reach a maximum temperature and this maximum temperature is not substantially improved by increases in the height of the stove. On the other hand, by increasing the cross section of the stove by removing the combustion chamber and filling it with ceramic media, as described herein in the present invention, it is possible to make the upper portion of the stove more efficient for two reasons—one—there is a greater cross-sectional area of heat absorbing media and hence the volume of media at the upper 20% of the stove is increased so that the capacity of the stove is increased without increasing the height of the stove and two, the upper 20% of the stove is heated directly and to a proportionately greater amount which is proper since its contribution in the heating cycle is approximately 80% of the entire heating function of the stove.

These results, as described, are achieved without in any way detracting from the service life of the refractory media, because the combustion while occurring at the point of maximum use in heat transfer is controlled in such a way that flame propagation will not occur into or against the checkerwork to consume the checkerwork. The described burner system is capable of use with leaning fuels and ones which require thorough and intimate mixing of the air and fuel.

The invention is also useful in retrofitting existing stoves. It has been found that the capacity of stoves can be materially increased, and without expensive alteration, by merely removing the existing combustion chamber from within the confines or envelope of the tower and filling such voided space with checkerwork and then disposing the heating chamber at the top of the tower within a frusto-conical combustion chamber or spherical combustion chamber, according to the preference of the builder. The conditions of combustion are then accurately controlled by regulating the inflow of combustible material or fuel, the inflow of air according to rate and amount to properly complete the process of combustion and regulate the propagation of flame within precise bounds.

The present invention is useful, of course, not only in the metal-producing industry but in many other industries as well where it is desired to supply substantial flows of heated gases in large amounts and rates and where such heating can be accomplished in an economical and safe manner.

The composition of the ceramic packing is not, it should be understood, essential to the present invention; any particular refractory packing, which is heat absorbent, stable and is capable of supporting its vertical weight is satisfactory so long as such refractory packing will develop flow paths so that the products of combustion can flow downwardly and the air blast can move upwardly through the packing to be heated thereby. It is also essential, of course, that such refractory material has sufficient heat resistivity that it will not disintegrate under conditions up to high heat and will not fuse or become joined together to plug the flows upwardly and downwardly, respectively, within the tower.

Although the present invention has been illustrated and described in connection with a single example embodiment, it will be understood that this is illustrative of the invention and is by no means restrictive thereof. It is reasonable to be expected that those skilled in this art can make numerous revisions and adaptations of the invention, and it is intended that such revisions and adaptations will be included within the scope of the following claims as equivalents of the invention.

1. An improved stove for heating air in metal-producing operations and the like, comprising a shell: a quantity of heat-absorbing refractory bodies contained in said shell and adapted to receive and store heat therein, means for selectively circulating a flow of hot, inert gases through said shell and which sweep over said hot and air blast, and means for providing a flow of combustion-supporting air which is caused to flow circularly
around the interior surface of the said conical chamber along a spiral path therein, the flow rate and speed of said combustion-supporting air being adjusted to locate the flame which is generated within said chamber.

4. A heating stove for providing a flow of air in heated condition for metal-producing operations, comprising in combination: support means defining a generally vertically extending heating chamber, a plurality of heat absorbing elements forming a relatively loose mass of such elements which provide flow paths therebetween, means defining an air inlet to provide a flow of air which is directed upwardly through the mass of heated articles and is heated thereby, a generally frusto-conically shaped combustion chamber at the upper end of said stove which provides a location of burning for generating heat for raising the temperature of said heat-absorbing elements, and a burner disposed in said chamber and having an inlet port which directs combustion-supporting gas tangentially relatively to the interior surface of said chamber and which spirally follows such interior chamber wall, fuel supply means adapted to inject fuel centrally in relation to said spiral inlet flow of combustion-supporting gas, and regulating means for controlling the rate of input flow of fuel and combustion-supporting gas to control the flame propagation and flame length within said combustion chamber.

5. A heating stove for providing a flow of air in heated condition for metal-producing operations, comprising in combination: support means defining a generally vertically extending heating chamber, a plurality of heat absorbing elements forming a relatively loose mass of such elements which provide flow paths therebetween, means defining an air inlet to provide a flow of air which is directed upwardly through the mass of heated articles and is heated thereby, a combustion chamber disposed generally collinearly with the mass of heat-absorbing elements and located at the upper end of the stove to provide a location of burning which generates heat for raising the temperature of said heat-absorbing elements, and a burner disposed in said chamber and having an inlet port which directs combustion-supporting gas tangentially relatively to the interior surface of said chamber and which spirally follows such interior chamber wall, fuel supply means adapted to inject fuel centrally in relation to said spiral inlet flow of combustion-supporting gas to control the flame propagation and flame length within said combustion chamber, and regulating means for controlling the rate of input flow.

6. An improved heating chamber for use in combination with a stove adapted for heating air in metal-producing operations and the like, comprising means defining an internal combustion chamber adapted for surmounting a vertical heating stove and defining the upper portion of said stove, means for injecting fuel interiorly of said chamber in combustible form and extending substantially centrally of said chamber, means providing an inlet flow of combustion-supporting gases which are caused to move tangentially of the interior surface of said chamber, and regulating means for determining the rate of inflow of such combustion-supporting gases to control the extent of flame propagation within said chamber.

7. An improved heating chamber for use in combination with a stove adapted for heating air in metal-producing operations and the like, comprising means defining an internal combustion chamber adapted for surmounting a vertical heating stove and defining the upper portion of said stove, means for injecting fuel interiorly of said chamber in combustible form and extending substantially centrally of said chamber, means providing an inlet flow of combustion-supporting gases which are caused to move tangentially of the interior surface of said chamber, regulating means for determining the rate of inflow of such combustion-supporting gases to control the extent of flame propagation within said chamber, and control means for regulating the inlet flow of injected fuel.

8. An improved heating chamber for use in combination with a stove adapted for heating air in metal-producing operations and the like, comprising means defining an internal combustion chamber adapted for surmounting a vertical heating furnace and defining the upper portion of said furnace, means for injecting fuel interiorly of said chamber in combustible form and extending substantially centrally of said chamber, means providing an inlet flow of combustion-supporting gases which are caused to move tangentially of the interior surface of said chamber, and regulating means for determining the rate of inflow of such combustion-supporting gases to control the extent of flame propagation within said chamber, said flame propagation being controlled to be confined entirely within said chamber and unimpinging against the stove in proximity therewith.

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