ABSTRACT

A coke oven battery is provided with a single burner in each flue of each heating wall. The vertical temperature profile of the heating wall is controlled by providing different combinations of low and high burners in the flues of each heating wall and in companion heating walls on opposite sides of the coke oven chamber. To provide 75 percent of the heat from the high burners there is provided a low burner in one flue and high burners in the next three flues. This pattern is repeated for each group of four flues in the heating wall. Another arrangement of high and low burners to provide 75 percent of the heat from the high burners and 25 percent of the heat from the low burners is to provide a high burner in each of the flues of the odd numbered heating walls and alternating high and low burners in alternate flues of the even numbered heating walls so that one heating wall has all high burners and the companion wall on the opposite side of the coking chamber has one-half high burners and one-half low burners. Other combinations of high and low burners are provided to obtain different percentages of the heat at the elevation of the high burners.

12 Claims, 9 Drawing Figures
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COKE OVEN HEATING SYSTEM

This application is a continuation of Application Ser. No. 863,292 filed on Oct. 2, 1969, and now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a regenerative coke oven battery having a single burner in each flue positioned at preselected elevations within the flue and more particularly to a regenerative coke oven battery having a single burner in each flue wherein the elevation of the burner in each flue is positioned at a preselected elevation to obtain a predetermined temperature profile along the length of the heating wall.

2. Description of the Prior Art

In the design and construction of horizontal regenerative coke oven batteries one of the primary objectives in recent years has been to increase coke oven capacity without adversely affecting the quality of the coke produced therein. To attain this objective the height of the coking chamber has been increased and each flue contains a high and low level burner. The high and low level burners within each flue supply heat to both the base of the flue and to the upper portion of the flue to more uniformly distribute the heat vertically along the heating walls and vertically through the coal charge in the coking chambers.

Consequently more piping is necessary to supply fuel gas to two burners than to a single burner in each flue. A plurality of burners in each flue further requires complicated and expensive brickwork design as compared with the brickwork design for a single gas burner in each flue. High and low burners in each flue require twice as many risers through the regenerator walls and increases the possibility of cracks or leaking joints developing between the risers.

Conventional coke ovens have a single rich gas burner located adjacent the base of the flue. With this arrangement the highest temperature zone in the vertical flue is concentrated next the base of the flues and insufficient heat is liberated in the upper portion of the flues. To circumvent this problem, conventional waste heat recirculation has been used and air ports have been provided at two or more levels in the flues so that only a sufficient amount of air is supplied to the base of the flues to burn a portion of the gas at the base of the flue. The remainder of the gas is burned adjacent the elevated air ports in the flues.

SUMMARY OF THE INVENTION

Briefly, the invention herein disclosed provides an improved means for burning different percentages of the total gas from the high burners and from the low burners to thereby control the vertical temperature gradient of the heating walls and the coal in the coking chamber. Each flue contains a single burner and the burners are positioned at preselected elevations so that a predetermined percentage of the heat liberation occurs at locations above the base of the flue. With this arrangement the temperature differential between the top and bottom of the coke cake is controlled by maintaining different vertical temperature differentials in the vertical flues. The vertical flues with low burners have a greater temperature differential from bottom to top than the flues with high burners. By properly distributing the number and location of flues with low burners and those with high burners, the desired average temperature distribution is obtained. The flow of heat through the brick from the vertical flues into the oven chamber tends to equalize the vertical temperature differential on the oven chamber side. The effective vertical heating of the oven charge, therefore, approaches the average vertical heating of the vertical flues.

Accordingly, the principal object of this invention is to provide a high chambered crossover regenerative coke oven battery having a single burner in each vertical flue where less than all the fuel gas is ignited and burned adjacent the base of the flue.

Another object of this invention is to provide a high chambered regenerative coke oven battery with one burner in each flue that has a low temperature differential between the top and bottom of the coke cake.

These and other objects and advantages of this invention will be more completely disclosed and described in the following specification, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section of a portion of a regenerative coke oven battery taken longitudinally of the coke oven battery and transversely to the length of the coking chamber.

FIG. 1 is taken along the line 1—1 of FIG. 2.

FIG. 2 is a vertical section of a portion of the regenerative coke oven battery illustrated in FIG. 1 taken transversely of the coke oven battery and parallel to the length of the coking chambers and illustrates both the heating flues and the coking chamber. Section A is taken along the line A—A in FIG. 1 and illustrates the vertical flues in section. Section B is taken through a coking chamber and regenerator and along the line B—B of FIG. 1.

FIG. 3 is a fragmentary view in section similar to a portion of FIG. 2 illustrating an arrangement of the high and low burners in the flues of a heating wall where 67 percent of the heat is provided adjacent the base of the flue and 33 percent of the heat is provided at a location above the base of the flue.

FIG. 4 is a fragmentary view similar to FIG. 3 illustrating another arrangement of the high and low burners in the flues of a heating wall where 25 percent of the heat is supplied to the heating wall adjacent the base of the flue and 75 percent of the heat is supplied to an elevated location.

FIG. 5 is a horizontal section in plan through a coke oven battery illustrating the burner arrangement in companion heating walls. Diagrammatically the circular gas port designates a low level burner, and a rectangular gas port designates a high level burner.

FIG. 6 is a view in section similar to FIG. 2 illustrating a flue arrangement for a heating wall where high burners are positioned in each of the flues.

FIG. 7 is a view similar to FIG. 6 illustrating a burner arrangement where there are alternating high and low level burners in adjacent flues in the same heating wall.

FIG. 8 is a view in horizontal section similar to FIG. 5 illustrating in plan another arrangement of burners in companion heating walls.
FIG. 9 is a graphical representation of temperature profiles of a heating wall utilizing various burner arrangements.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring to the drawings and particularly to FIG. 1 there is illustrated a regenerative coke oven battery generally designated by the numeral 10 that has a plurality of transversely extending coking chambers 12 spaced from each other with a heating wall 14 therebetween. The heating walls each include a plurality of spaced flues generally designated by the numeral 16 extending lengthwise thereof. Groups of the flues in one heating wall are connected to similar groups of flues on the opposite side of the coke oven by means of the crossover ducts 18.

Beneath the heating walls 14 and coke oven chambers 12 there are a plurality of regenerator chambers 20 that are separated by pillar walls 22 beneath the heating walls 14 and division walls 24 beneath the coking chambers 12. The pillar walls 22 serve to support the heating walls 14 and to divide the regenerative space beneath the heating walls and the coking chambers into a plurality of individual regenerator compartments 20 that extend across the battery and substantially parallel to the heating walls. The regenerator positioned between the pillar walls is further subdivided into a pair of regenerator compartments 20 by the division wall 24 which serves to support the coal charge in the coking chamber thereabove. Each regenerator compartment has a sole flue 26 that communicates by a plurality of vertical ducts or passageways 28 with the regenerator compartments 20 therebelow. The sole flues 26 are connected at opposite ends to flow boxes 30 for regulating the flow of the air that enters the regenerators for preheating purposes. The combustion gases from the regenerator compartments 20 are discharged through the conduit 32 into a stack canal 34. Combustion air is supplied through inlet 36 to the regenerator compartments associated with the "on" flues in the heating walls and combustion gases are discharged from the regenerator compartments 20 associated with the "off" flues. The regenerators are supported on a concrete pad 38 which is positioned above ground level to provide a battery basement 40 in which the gas main 42 is positioned and connected to a plurality of parallel transverse gas supply headers 44. One transverse header 44 is associated with each heating wall 14.

Referring more particularly to FIG. 2, for ease in reference the vertical flues in the heating wall illustrated in section will be designated alphabetically beginning with the flue adjacent side 46 of the coke oven battery and all of the flues in the remaining figures will be referred to by the same capitalized alphabetical designation although the burner arrangements in the flues in the remaining figures are different. The heating wall 14 is divided into vertical flues by a plurality of transverse division walls 48, 50, 52, 54, 56, 58, 60 and 62. The division walls extend transversely between and are joined to the spaced elongated flue heat transfer walls 64 and 66. The flue heat transfer walls 64 and 66 extend parallel to the coke oven chambers on opposite sides thereof and heat is transferred therethrough to the coke in the adjacent coking chambers 12.

The flue division walls 48 and 56 are connected to the roof 68 by the extensions 70 and the remaining division walls terminate therebelow to form a horizontal passageway 72 connecting a group of flues with the crossover duct 18. With this arrangement the products of combustion from groups of the "on" flues are conveyed through the crossover duct into companion groups of "off" flues on the opposite side of the coke oven chamber 12.

Each of the flues contain a single burner which, for convenience, will be designated in all of the figures by the lower case letter l when the gas port of the burner is located adjacent the base of the flue and by the lower case letter h when the gas port of the burner is located at an elevated position as, for example, between about 4 and 6 feet above the base of the flue in a battery having coke oven chambers between 17 and 20 feet high.

The base of each flue is connected to the regenerators therebelow by passageways 74. Preheated combustion air is supplied through these passages to the "on" flues from the regenerator compartments located therebelow. Waste combustion gases from the "off" flues flow through the passageways 74 into the regenerator compartments positioned therebelow. The burners in each flue of a heating wall are connected by a single vertical riser 76 to the horizontal transverse header 44 located in the basement 40. The vertical risers 76 extend upwardly through the pillar walls 22 that separate the regenerator compartments. With this arrangement all of the burners in the "on" flues of a heating wall are supplied with fuel gas from the same horizontal header 44. The metering of the desired volume of gas to each flue is controlled by nozzles connected to the piping from header 44 and extending into recirculating ducts in pad 38. The vertical risers 76 are large enough so that metering is done by small orifices in the nozzles. Combustion takes place within the flues at the port so that, in effect, with a low burner combustion takes place adjacent the base of the flue and with a high burner combustion takes place at the elevated location of the high burner.

Referring to FIG. 2 flue A has a low burner 1 and adjacent flues B and C each have a high burner h. Flue D has a low burner l and flues E and F each have a high burner h. Flue G has a low burner l so that the flues in the heating wall can be conveniently grouped into three flues having sequentially a low burner, a high burner, and a high burner. This pattern is repeated throughout the length of the heating wall. With the above described arrangement, 33 percent of the combustion takes place at the base of the heating wall, and 67 percent of the combustion takes place at the elevated location of the high burners.

It has been determined that there is substantial equalization of heat flow in a horizontal direction along the length of the flue heat transfer walls 64 and 66 from one flue to the other as the heat is conducted through the silica brick heat transfer walls 64 or 66 between the flues 16 and the oven chamber 12. It was also discovered that there is a substantial vertical distribution of heat by radiation within the flues and by conduction as the heat flows through the silica heat transfer walls 64 and 66 between the flues and the oven chambers 12. There is thus a tendency to equalize the flow of heat to a considerable extent along the heating walls even where the burners are located at different elevations in
the flues of the heating wall. Thus, with the burners arranged as illustrated in FIG. 2, equalization of the heat occurs to uniformly distribute the heat horizontally along the heat transfer walls and into the coke oven chamber 12. In FIG. 2 substantially the same heat distribution is obtained as with a coke oven battery having both high and low burners in each flue.

FIG. 3 illustrates another arrangement of the burners in flues A through G to provide 67 percent of the heat at the base of the heating wall and 33 percent of the heat at an elevated location. With this arrangement there is provided in flue A a high level burner h and in adjacent flues B and C there are low level burners l. Flue D has a high level burner and flues E and F have low level burners with adjacent flue G having a high level burner.

Where it is desired to provide 25 percent of the combustion adjacent the base of the heating wall and 75 percent of the combustion at an elevated location, an arrangement similar to that illustrated in FIG. 4 may be used. Flue A has a low level burner and adjacent flues B, C and D have high level burners. The next flue E has a low level burner. The following three flues F, G and H have high level burners. The remainder of the heating wall may be divided into similar groups as illustrated in FIG. 4 to provide 25 percent of the combustion adjacent the base of the flue and 75 percent of the combustion at an elevated location to obtain the desired vertical heat distribution in the flue transfer walls 64 and 66.

FIG. 6 illustrates a heating wall 14 where all of the combustion takes place at a location above the base of the flue in that all of the flues A through H have high level burners h.

FIG. 7 illustrates another arrangement of a heating wall 14 where 50 percent of the combustion takes place adjacent the base of the flue and 50 percent of the combustion takes place at an elevated location. With this arrangement the high and low level burners are alternately arranged in the adjacent flues.

Now referring to FIG. 5 there is illustrated a plurality of parallel heating walls, for this figure generally designated by the numerals 80, 81, 82, 83, 84 and 85, with coking chambers 12 therebetween. The flues 16 in heating wall 80 have alternating high and low burners as indicated by the letters h and l by a rectangular gas port for a high burner and a circular gas port for a low burner. The flues 16 of the heating wall 80 are connected with the flues of the heating wall 81 by overset duct 18 as illustrated in FIG. 1. The flues 16 in heating wall 81 all have low burners so that combustion takes place adjacent the base of the flue. With this arrangement 75 percent of the combustion takes place at the low burners and 25 percent of the combustion takes place at the high burners in the pair of companion heating walls 80 and 81. The burners in the even numbered flues 80, 82 and 84 have alternate high and low burners across the heating wall. The odd numbered walls 81, 83 and 85 all have high burners. Thus, one heating wall has all low burners and the companion heating wall on the opposite side of the coke oven chamber has one-half high burners and one-half low burners, providing 75 percent low burners and 25 percent high burners for each pair of companion walls.

FIG. 8 illustrates another arrangement where 75 percent of the combustion is provided from the high burners and 25 percent of the combustion is provided from the low burners. The heating walls are designated in this figure by the numerals 87, 88 and 89. The odd numbered heating walls have all high burners therein similar to that illustrated in FIG. 6. The even numbered heating walls have alternate high and low burners similar to that illustrated in FIG. 7. With this arrangement, 25 percent of the combustion takes place at the base of a pair of companion flues and 75 percent of the combustion takes place at an elevated location.

It will be readily apparent that similar combinations are possible so that 20 percent, 25 percent, 33.3 percent, 40 percent, 60 percent, 66.7 percent or 80 percent of the combustion gas is supplied to high burners and the balance to the low burners in either a single heating wall or a pair of companion heating walls. For example, a heating wall, although not illustrated, may have a plurality of groups of five flues, each group having sequentially a high burner a low burner, a high burner, a low burner and a high burner so that about 60 percent of the combustion takes place at a location above the base of the heating wall. Also, where it is desired to have a total of about 62.5 percent of the combustion take place at an elevation above the base of the heating walls of companion flues, one of the companion heating walls may have a plurality of groups of four flues arranged sequentially with a low burner, a high burner, a high burner and a high burner and the adjacent companion heating wall may have a plurality of groups of four flues arranged sequentially with a high burner, a low burner, a high burner and a low burner so that about 62.5 percent of the combustion takes place at a location above the base of the heating wall.

FIG. 9 illustrates graphically plots of actual flue wall temperature measurements taken in coke oven batteries having three different fuel gas burner arrangements. All of the temperature profiles have been moved to a common point of 2,400°F. at 1.4 feet above the base of the flue for ease of profile comparison. All temperatures were taken starting approximately 15 minutes after the reverse cycle. Curve A illustrates the flue wall temperature profile of a conventional coke oven having 100 percent of both the air and fuel gas admitted to the base of the flue in all of the flues of the battery. It is apparent from this curve that the temperature profile decreases approximately 300°F. between the base and the top of the flue wall.

Curve B illustrates the average flue wall temperature profile of a battery of a tall modern coke oven having a burner arrangement with one fuel gas burner per vertical flue, the burners in the flues alternating one high level burner and one low level burner similar to that illustrated in FIG. 7. The profile of curve B is the average of the profiles of one flue having a high burner and one flue having a low burner. The temperature differential between the base of the flue and the top of the flue oven is less than 200°F. The distance between the base of the flue and the top of the flue is also substantially greater by 4 feet from that of curve A. If the same upper elevation between curve A and curve B is compared, the temperature differential between the bottom of the flue and this common elevation in curve B is less than 100°F. as compared with the 400°F. differential of curve A.

Curve C illustrates the flue wall temperature profile using another gas burner arrangement where the burners across the length of the heating wall are arranged
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in successive groups of three flues each with a single burner in each flue and each group having two high burners and one low burner. The profile of curve C is the average of temperatures taken in three flues of such a group. This arrangement provides approximately 67 percent of the fuel to the high burners and 33 percent of the fuel to the low burners. It is apparent in comparing curves B and C that the increase in the per cent of fuel supplied to the high burners reduces the temperature differential in the profile below that illustrated in curve B where 50 percent of the fuel is supplied to the high burners.

With the above discussed arrangements of the high and low burners in the flues of each heating wall or companion pairs of heating walls, it is now possible to supply the same amount of fuel to each of the burners and to accurately control the per cent of the fuel burned at various elevations of the heating wall. Although only low and high level burners have been described and illustrated, it should be understood arrangements of low, intermediate and high burners could be used to further control the temperature profile of the heating wall.

It is not practical to burn substantially more than 50 percent of the rich gas in either the high or low burners because of inherent dangers. For example, if 75 percent of the fuel is provided for alternate high burners and 25 percent for alternate low burners, the temperature in the high burner flues would be considerably higher than the temperature in the low burner flues. This condition would result either in dangerously high temperatures in the high burner flues or in undesirably low temperatures in the low burner flues, thus resulting in a reduced cooking rate. It is, therefore, preferred to supply substantially the same volume of gas to each burner compensating for oven taper between the pusher side and the coke side of the oven and to control the elevation of the burners. The volume of gas supplied to each flue increases from the pusher side to the coke side of the oven because of the greater weight and volume of coal on the coke side due to oven taper. Therefore, for any flue position from pusher side to coke side, the volume of gas required is determined by the amount of coal to be heated, regardless of the position of the burner in the flue.

According to the provisions of the patent statutes, the principle, preferred construction and mode of operation of this invention have been explained and what is considered to represent its best embodiments have been illustrated and described.

I claim:

1. A high chambered regenerative coke oven battery comprising,
a plurality of spaced parallel coking chambers arranged transversely across said coke oven battery and having a height between 17 and 20 feet, transverse heating walls positioned between said coking chambers and arranged to supply heat to said coking chambers,
each of said heating walls having a pair of parallel spaced heat transfer walls, a base portion and a plurality of spaced division walls extending transversely between said heat transfer walls to form a plurality of separate heating flues in each heating wall,
each of said heating flues having openings in said base portion for the flow of combustion supporting gas into said flues,
a plurality of spaced crossover ducts extending over said coking chambers and connecting groups of flues in companion heating walls on opposite sides of said coking chambers so that hot combustion gases flowing upwardly in groups of flues on one side of said coking chambers flow through said crossover ducts and downwardly through said groups of flues on the opposite side of said coking chambers,
regenerators positioned beneath said heating walls and said coking chambers with passageways connecting said regenerators to said flues,
said regenerators having elongated division walls forming elongated regenerator chambers,
a fuel gas supply conduit extending longitudinally relative to said coke oven battery,
fuel gas supply headers extending transversely from said gas supply conduit parallel to said heating walls with a single header arranged to supply fuel gas to all of said flues in the same heating wall,
vertical riser passages in said regenerator division wall connected to said transverse header therebelow extending upwardly into said heating flue with a single vertical riser passageway for each flue,
said vertical riser passageways terminating in single burners in each flue arranged at preselected different elevations in said flues with certain of said burners located at an elevation between about 4 and 6 feet above other burners located at a lower elevation so that less than all of the fuel gas is ignited and burned at a location adjacent the base of the heating wall to thereby increase the temperature of the heating walls at an elevation above the base of said heating walls.

2. A high chambered regenerative coke oven battery as set forth in claim 1 in which certain of said burners are low burners located at the base of said heating walls and other of said burners are high burners located at the same elevation above the base of said heating walls.

3. A high chambered regenerative coke oven battery as set forth in claim 2 in which,
a heating wall has a plurality of groups of four flues, each group of flues having a single burner in each flue arranged sequentially in said group of four flues as a low burner, a high burner, a high burner and a low burner so that fifty percent of the combustion takes place at the base of the heating walls and 50 percent of the combustion takes place at a location above the base of the heating walls.

4. A high chambered regenerative coke oven battery as set forth in claim 2 in which,
a heating wall has a plurality of groups of four flues, said groups having a single burner in each flue, said groups have sequentially a high burner, a low burner, a high burner and a low burner so that about 50 percent of the combustion takes place at a location above the base of the heating wall.

5. A high chambered regenerative coke oven battery as set forth in claim 2 in which,
a heating wall has a plurality of groups of four flues, said groups having a single burner in each flue arranged sequentially in said groups as a low burner,
9. A high chambered regenerative coke oven battery as set forth in claim 2 in which, a heating wall has a plurality of groups of three flues, said groups having a single burner in each flue arranged sequentially in said groups as a high burner, a low burner and a high burner so that about 67 percent of the total fuel gas ignited and burned during a complete cycle of combustion in both companion flues is at an elevation above the base of said heating walls of said companion flues.

10. A high chambered regenerative coke oven battery as set forth in claim 7 in which, one companion heating wall has single burners in each flue with all high burners and the other companion heating wall has single burners in each flue with all low burners so that about 50 percent of the fuel gas ignited and burned during a complete cycle of combustion in both companion flues is at an elevation above the base of said heating walls of said companion flues.

11. A high chambered regenerative coke oven battery as set forth in claim 2 in which, a heating wall has a plurality of groups of five flues, said groups having sequentially a high burner, a low burner, a high burner, a low burner, and a high burner so that about 60 percent of the combustion takes place at a location above the base of the heating wall.

12. A high chambered regenerative coke oven battery as set forth in claim 7 in which, one companion heating wall has a plurality of groups of four flues, said groups having a single burner in each flue arranged sequentially in said group of flues as a low burner, a high burner, a high burner and a low burner and the other companion heating wall has a plurality of groups of four flues, said last named groups having a single burner in each flue arranged sequentially in said group of flues as a high burner, a low burner, a high burner and a low burner so that about 62½ percent of the fuel gas ignited and burned during a complete cycle of combustion in both companion flues is at an elevation above the base of said heating walls of said companion flues.