ABSTRACT: A method of apparatus for operating a furnace, such as of the soaking pit, walking beam, or car types, wherein the furnace enclosure is formed by stationary elements or walls as well as at least one movable element or wall. The movable portion of the enclosure is spaced from the stationary portion to provide clearance for relative movement therebetween. The waste gases of combustion are diverted while en route to an exhaust stack, are cooled to a suitable temperature, and are directed into and through the space between the stationary and movable portions to create a pressure barrier therebetween. In this manner, superatmospheric waste gases within the furnace are contained and the atmosphere within the furnace is maintained so that it will not have a deterrent effect on the surface of the ingots, slabs or billets being heated, i.e. it does not add to the scale problem.
Fig. 6

Fig. 7

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METHOD OF AND APPARATUS FOR OPERATING A FURNACE

This invention relates to a method of and apparatus for operating a furnace, and more particularly to the operation of soaking pits, walking beam and car types of furnaces. The invention has application to other types of furnaces, but, by way of example, will be discussed in detail herein with respect to the soaking pit type of furnace. In soaking pits there can be provided a peripheral gap between its walls and a movable top cover plate. In accordance with the invention a pressure barrier is established at the peripheral gap by waste gases, which may be cooled, from the soaking pit itself.

Heretofore, it has been proposed to use air in order to provide containment of gases within a furnace of the type contemplated herein. However, it has been found that despite efforts to maintain an even pressure balance, there is an interchange of atmospheres at the gap between the top of the sidewalls and the cover plate which results in a seepage of air which becomes heated oxidizes the ingots, slabs or billets and increases the scale formation.

In accordance with the present invention, the waste gases of combustion, which are substantially devoid of oxygen are diverted from a waste gas exhaust system and directed into and through the space between the movable and stationary portions of the furnace enclosure in order to create a pressure barrier therebetween which will contain superatmospheric waste gases within the furnace. By this method and apparatus additional scaling of the material charge within the furnace is prevented.

In a preferred form of the invention, the waste gases are cooled by external means after being diverted from the exhaust system. Before diverting the waste gases it is preferred to pass the waste gases through a recuperator wherein a substantial amount of the heat of combustion is recovered and used to preheat the air for combustion thereby effecting an economy of fuel.

After diverting the waste gases en route to the exhaust stack, the waste gases are cooled to a temperature below 800°F and preferably cooled to a temperature between about 500°F and about 600°F. In order to provide an adequate containment of the gases within the furnace, it is preferred to control the pressure of the waste gases so as to provide a flow rate of cooled waste gases of about 30 standard cubic feet per minute per foot of length into and through the peripheral gap atop an individual furnace, such as a soaking pit.

The inherent advantages and improvements of the present invention will become more readily apparent upon considering the following detailed description of the invention and by reference to the accompanying drawings in which:

FIG. 1 is a top plan view showing the general arrangement for a battery of soaking pits;
FIG. 2 is a side elevational view, taken partially in vertical cross section, illustrating a typical soaking pit;
FIG. 3 is a fragmentary top plan view of a single soaking pit of FIG. 1, drawn to an enlarged scale;
FIG. 4 is a top plan view showing a further enlargement of the connections to the pressure equalization device;
FIG. 5 is a fragmentary elevational view taken in vertical cross section along line 5—5 of FIG. 3;
FIG. 6 is a fragmentary elevational view in vertical cross section of one side of a typical soaking pit;
FIG. 7 is a fragmentary end elevational view showing an end of a typical soaking pit and cover member therefor;
FIG. 8 is a fragmentary side elevational view of a walking beam furnace embodying the instant invention;
FIG. 8A shows in detail the waste gas seal applied to the walking beam furnace;
FIG. 9 is a fragmentary side elevational view of a car type of furnace embodying the instant invention; and,
FIG. 9A shows in detail the waste gas seal applied to the car type furnace.

Referring now to FIG. 1, there are illustrated a battery of soaking pits, identified generally at 10, 12, 14 and 16, with each soaking pit being provided with upstanding vertical sidewalls as shown at 11 in FIG. 2. Walls 11 together with a bottom 15 and a spaced cover, indicated generally at 17, provide an enclosure for material charged into the pit, for example, ingots, slabs or billets shown in phantom at 18. The waste gases of combustion from each soaking pit are removed therefrom in a waste gas handling system. The latter is shown to include a conduit means indicated generally at 20 by which the waste gases are delivered to a series of recuperators 22 with the aid of draft from a chimney or exhaust stack 23. For purposes of this invention, recuperators 22 are conventional in design and used to remove some of the heat of combustion from the waste gases and to return it directly to the fuel economy measure. The spent waste gases are fed outwardly from recuperator 22 under the control of a series of dampers such as are indicated at 24 in a series of conduits 26. These waste gases which retain a residual heat of 1,000°F or more, depending upon the type of recuperator used, are then collected in collector manifolds 28, the principal stream of which is toward a chimney or exhaust stack 30.

As seen best in FIG. 2, each soaking pit is provided with a motor 25 which helps to propel a mixture of fuel and gas through conduit 27 into the soaking pit. It has been found that soaking pits operated in accordance with the present invention have fewer flameouts than was experienced heretofore.

However, in accordance with the present invention, means such as diverter conduits 32 are used to divert a portion of the waste gases in order that they may be returned and directed into and through the vertical space between the continuous sidewalls 11 and cover 17 in order to contain superatmospheric waste gases within the soaking pit and thereby prevent additional scaling of the metallic charge 18 within the soaking pit.

One suitable apparatus for cooling the waste gases is shown in the form of a water spray manifold 34 which directs water into the diverted waste gases in order to cool them below 800°F and preferably between 500°F and 600°F. It is to be understood, however, that the waste gases may also be cooled by a heat exchanger or an additional recuperator, but the water spray has the advantage of both cooling and cleaning the waste gases. The waste gases are then withdrawn along pipe 36 under the influence of a blower 38 and thence through return manifold 40 toward the soaking pits. It is preferred to control the pressure of the waste gases in order to obtain a desired flow rate into and through the peripheral gap atop the walls 11 of each soaking pit. For this purpose each return manifold 40 is shown to have a valve control 41 located therein. Alternatively, a valve may be positioned further downstream such as in pipes 50, FIG. 5, in order to be associated with an individual soaking pit. In this manner the pressure can be varied so as to maintain a positive flow of gas into the soaking pit, thereby preventing the outward escape of hot gases from within the soaking pit.

The return flow is divided into two paths in pipes 42 and 44 the latter also being redirected in manifold 45. Thereafter, feeder lines indicated only schematically at 46 return the cooled waste gases through riser members 48 (FIGS. 3—5) and connector pipes 50 into a peripherally arranged conduit 52 which is provided with a redirecting means such as nozzles 54. While the detailed conduit return means is shown only for soaking pit 10, it is to be understood that comparable conduit return means are provided for each of the remaining soaking pits 12, 14, and 16 in the battery of soaking pits. Also, while nozzles 54 are shown, it is to be understood that inlets in the conduit 52 would suffice to redirect the waste gases.

Reference to FIGS. 4 and 5 will show that the waste gases are returned through riser member 48 thence through connector pipes 50, the waste gases enter the peripheral manifold 52 whereby the waste gases may be directed as indicated from the exhaust of nozzles 54. Each connector pipe 50 is located above a recessed surface 56 a spaced series of which extend peripherally around the rim of an individual soaking pit. Each cover member 17 is shown to consist of a cover indicated specifically at 60 and an end plate 61. Each cover is spaced
approximately 2 to 3 inches above the top surface 62 of the continuous sidewalls 11, although this can be varied according to other parameters and variables of design. This space is indicated by numeral 64 and is into this space that the discharge from nozzles 54 is directed so as to create a pressure barrier between wall 11 and cover 60. The supernumerary waste gases are contained within the soaking pit, and the additional scaling of the metallic material charge 18 within the soaking pit, which occurs when oxygen containing gases are injected into the pit, is prevented.

Because of the space between the walls 11 of the soaking pit and the cover 17, it is no longer necessary to provide means for lifting the cover. Instead it is only required that the cover 17 horizontally traverse the opening above an individual soaking pit in order to load the pit with billets, slabs or ingots. In order to effect the traverse of the cover 17 in a horizontal plane, wheels 80 which ride on suitable I-beams or rails which provide track members 82 permit the soaking pit to be opened and closed in order to load and unload material for treatment within the soaking pit. For purposes of this invention, the means to effect the traverse of the cover to permit the loading and unloading of the soaking pit are conventional.

In operation, and with billets, slabs or ingots 18 within an individual soaking pit, the waste gases are drawn from the furnace under the influence of chimney or exhaust stack 30 and caused to flow into a recuperator 22. The waste gas from the recuperator 22 flowing toward chimney or exhaust stack 30 have a portion thereof diverted into conduits 32 where they are cooled by being sprayed from water spray manifolds 34 prior to being redirected through conduits 36 with the aid of blower means 38 toward the soaking pits. The diverted and cooled waste gases are returned through conduit means as shown in FIG. 1 ultimately to riser members 48 and then laterally toward peripheral manifold 52. Nozzles 54 within manifold 52 or other suitable directing apparatus direct the cooled waste gases toward the peripheral space 64 between the top surface 62 of the upstanding sidewalls 11 and the bottom surface of cover 66 in order to create a pressure barrier for the gases within the soaking pit.

For purposes of illustration only, a soaking pit with an input of 30 million BTU's would yield approximately 330,000 standard cubic feet per hour of waste gas. Approximately 10,000 to 12,000 cubic feet per minute is diverted from the exhaust stack 30 in order to be cooled and returned to the soaking pit. Inorder to conserve, the exhaust gases from the soaking pits in the order of approximately 2,400°F. are reduced depending upon the type and presence of a recuperator from about 1,800°F. to about 1,000°F. If it is preferred to cool the gases by the water spray manifold means 34 to below 800°F. and preferably between about 500°F. and 600°F. Therefore, it is possible to obtain a flow at the peripheral manifold 52 of approximately 30 standard cubic feet per minute per foot of length around the periphery of the soaking pit. While the cover 17 is illustrated to be dome-shaped, this is immaterial insofar as the present invention is concerned and a flat cover will work equally as well.

Referring to FIG. 8, there is shown a walking beam furnace 99 which incorporates a waste gas seal in accordance with the instant invention. The walking beam furnace 99 includes sidewalls 91 and 92 and a top cover 93. The ends of the furnace are enclosed with additional walls (not shown). The hearth or bottom of the furnace if formed of a plurality of movable beams 94, and alternately spaced stationary beams 96. The movable beams 94 are raised, advanced, lowered, and then retracted by drive mechanisms 97 to walk the workpiece W through the furnace in a well-known manner. See, for example, U.S. Pat. No. 1,973,934 issued to Stevens and U.S. Pat. No. 2,056,070 issued to Menough for typical drive mechanisms.

The enclosure formed by the sidewalls 91 and 92, the top 93 and the movable and stationary beams, 94 and 96, respectively, may be heated to several thousand degrees Fahrenheit for reheating ingots, slabs, etc. prior to rolling, extruding, forging or heat treating. Hot gases are normally supplied through the top cover from above in order to heat the interior of the furnace, although the gases can also be injected from the sides in some furnace designs.

Referring to FIG. 8A, there is shown in detail adjacent movable and stationary beams, 94 and 96, respectively, having a space or clearance 98 therebetween to prevent the passage of gases through the spaces 98 (either hot gases moving out or relatively cool air moving into the furnace) nozzles or apertured pipes 99 are provided. The nozzles 99 are supplied with waste gases which are removed from the furnace via a collector 101 and a flue 102. A portion of the waste gases are diverted by a line 103 which connects to the nozzles 99. As shown, the nozzles are directed such an angle so as to force the waste gases into the space 98 to provide a seal which in principle operates the same as on the soaking pit, described previously.

It is to be understood that the nozzles or apertured pipes 99 extend the entire length of the furnace 90 and are directed into the spaces formed between each of the movable and stationary beams. Furthermore, a waste gas seal may be provided at each end of the furnace for preventing undesirable passage of air or heated gas therethrough. The flow of waste gases may be controlled by a valve 104. Additionally, the gases may be cooled by means (not shown) if desired.

Referring to FIG. 9, there is shown a third type of furnace, normally referred to as a car-type furnace, generally designated 110. In this type of furnace the sidewalls 111 and the top cover 112 are stationary, whereas the floor 113 of the furnace is mounted on wheels 114 for movement into and out of the furnace chamber. The ends of the furnace 110 are closed by doors of well-known design once the movable hearth or car 113 is positioned inside the furnace chamber. This type of furnace is frequently used for heating workpieces W, such as ingots, slabs, etc., for forging, annealing, normalizing, and heat treating. The hot gases 121 are directed into the furnace chamber through openings such as 116. The waste gases are removed by a flue 117 leading to a stack 118.

As in the previous embodiments, a space or clearance 119 is provided between the movable hearth 113 and the stationary portion of the enclosure, in this case, the sidewalls 111. As shown in greater detail in FIG. 9A, the sidewalls 111 are provided with angularly directed passageways 121 into which waste gases are fed. The waste gases can be the product of the combustion substantially devoid of oxygen from a waste gas exhaust system which receives waste gases from said furnace, or for heat treating. Hot gases are normally supplied through the top cover from above in order to heat the interior of the furnace, although the gases can also be injected from the sides in some furnace designs.

What is claimed is:

1. A method of operating a furnace of the type having an enclosure formed in part with stationary structural members and in part with movable members, said stationary and movable members being spaced from one another to provide a clearance, comprising the steps of:
   a. diverting waste gases of combustion substantially devoid of oxygen from a waste gas exhaust system which receives waste gases from said furnace,
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b. directing said diverted waste gases into and through the space between said stationary and movable members to create a pressure barrier therebetween in order to contain superatmospheric waste gases within said furnace thereby preventing additional scaling of a material charge within said furnace, and

c. controlling the pressure of said waste gases which are diverted into and through the spaces between the stationary and movable members.

2. A method of operating a walking beam type of furnace having a bottom enclosure formed of longitudinally extending stationary support members, and movable support members alternately positioned between and parallel to the stationary members for walking workpieces through the furnace, and wherein the stationary and movable members are spaced laterally from one another to provide a clearance, comprising the steps of:

a. diverting waste gases of combustion substantially devoid of oxygen from a waste gas exhaust system which receives waste gases from said walking beam type of furnace,

b. and directing said diverted waste gases into and through the space between said stationary and movable support members to create a pressure barrier therebetween in order to contain superatmospheric waste gases within said walking beam type of furnace thereby preventing additional scaling of a material charge within said walking beam type of furnace.

3. A method of operating a car-type furnace of the type having a stationary furnace chamber having upstanding sidewalls and a top, and a horizontally movable car for supporting the workpieces in the furnace, said movable car and the upstanding sidewalls being spaced laterally from one another to provide a clearance comprising the steps of:

a. diverting waste gases of combustion substantially devoid of oxygen from a waste gas exhaust system which receives waste gases from said car-type furnace,

b. and directing said diverted waste gases into and through the space between said car and the upstanding sidewalls to create a pressure barrier therebetween in order to contain superatmospheric waste gases within said car-type furnace thereby preventing additional scaling of a material charge within said car-type furnace.

4. A method of operating a soaking pit of the type having an enclosure formed by a bottom and upstanding sidewalls together with a top cover spaced slightly vertically therefrom comprising the steps of:

a. diverting waste gases of combustion substantially devoid of oxygen from a waste gas exhaust system which receives waste gases from said soaking pit,

b. cooling said waste gases to a temperature below 800° F.,

c. and directing said diverted waste gases into and through the vertical space between said upstanding sidewalls and through the vertical space between said upstanding sidewalls and said top cover to create a pressure barrier therebetween in order to contain superatmospheric waste gases within said soaking pit thereby preventing additional scaling of material charge within said soaking pit.

5. A method of operating a soaking pit as defined in claim 4 including the additional step of controlling the pressure of said waste gases which are diverted into and through the vertical space between said upstanding sidewalls and said cover.

6. A method of operating a soaking pit as defined in claim 5 wherein said step of controlling the pressure of said waste gases establishes a waste gas flow rate per unit length into the vertical space between said upstanding sidewalls and said top cover of about 30 standard cubic feet per minute per foot of length.

7. A method of operating a soaking pit as defined in claim 4 including the additional step of cooling said waste gases to a temperature between about 500° and about 600° F.

8. A method of operating a soaking pit as defined in claim 4 including the additional step of flowing said waste gases through a recuperator prior to said step of diverting said waste gases from said exhaust system.

9. A method of operating a soaking pit as defined in claim 4 including the additional step of subjecting said diverted waste gases to a water spray, said water spray serving to clean said waste gases as well as to reduce the temperature thereof.

10. In combination with a furnace of the type formed in part with stationary structural members and in part with movable members, said stationary and movable members being spaced from one another to provide a clearance, and further incorporating a waste gas exhaust system in communication with said enclosure, the improvement which comprises:

a. means for diverting waste gases of combustion from the waste gas exhaust system;

b. means for directing said diverted waste gases into and through the space between said stationary and movable members to create a pressure barrier therebetween in order to contain the superatmospheric waste gases within said furnace while minimizing the scaling of a material charge within the soaking pit,

c. and, means for controlling the pressure of said waste gases into and through the space of the stationary and movable members to prevent outward escape of gases within the soaking pit through said space.

11. A furnace as recited in claim 10, which further comprises:

a. means for cooling said waste gases prior to directing the gases into said space.

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