BASIC ROOF CONSTRUCTION FOR A METALLURGICAL FURNACE

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Fig. 1

Fig. 2

Fig. 3

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Basic Roof Construction for a Metallurgical Furnace

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This invention relates to an improved all-brick roof for metallurgical furnaces, particularly roofs of open hearth steel furnaces.

For years it has been known that basic refractories, i.e., those composed of chrome ore and magnesite, possess certain characteristics which are desirable for high temperature service. From a steelmaker's viewpoint, the most important feature of basic brick is its ability to absorb large quantities of molten iron oxide without substantial loss in refractoriness. Furthermore basic brick is more resistant than silica brick to cycling reducing-oxidizing atmospheres containing iron oxide at elevated temperatures. However, basic bricks cost more than silica bricks generally used in open hearth roofs and have the additional disadvantages of greater weight, higher reversible expansion, greater growth from iron oxide absorption and lower load bearing capacity at elevated temperatures.

In order to capitalize on the ability of basic bricks to withstand high temperatures, present all-brick roof construction requires an intricate steel structure to support the bricks and to control the roof contour. In addition to the expense of the suspension steelwork, a large amount of labor is needed to assemble this type of roof.

It is an object of the present invention to provide an all-basic brick furnace roof in which the suspension features heretofore thought necessary for basic bricks are eliminated.

Another object is to provide an all-basic brick furnace roof which can be rapidly assembled.

It is a further object to provide an all-basic brick furnace roof which will have a life equal to, but which will cost substantially less than, all-basic furnace roofs now in service.

Contrary to the long held views of those skilled in the furnace art, I have discovered that it is possible to erect a fully sprung arch type all-basic brick furnace roof which does not require suspension means for the brickwork and which will achieve a roof life equal to that of present all-basic roof designs. The all-basic roof of my invention has the bricks arranged in rows extending longitudinally of the furnace with overlapping transverse joints, i.e., bonded construction, and is held down by contour control beams but is not suspended. By bonding the bricks in this fashion, each brick is partially supported by contiguous bricks and in like fashion partially supports them. The sprung arch and bonded arrangement of the brickwork in the basic brick roof of my invention eliminates the need for a suspension system to support the bricks, and therefore is considerably more economical than basic roofs of previously conventional design. In addition to the savings obtained by the elimination of the suspension steelwork, there is a considerable reduction in the number of man hours required to lay the brickwork.

Other and additional features and advantages of the present invention will become apparent from the following specification and the accompanying drawings, in which:

FIG. 1 is a sectional view of a sprung arch roof in accordance with the present invention.

FIG. 2 is a fragmentary plan view of the sprung arch roof of FIG. 1, with the beams and jacks omitted.

FIG. 3 is a fragmentary plan view of a different embodiment of my roof construction.

For purposes of illustration this invention will be described with particular reference to open hearth steelmaking furnaces, but it is not necessarily limited thereto.

Referring now to the drawing, there is shown in FIGURE 1 a furnace framework consisting of vertical buckstays 16, at the front and rear of the furnace, connected at their tops by cross-channels 11 which span the roof transversely of the furnace. Heavy channels 12 extend longitudinally of the furnace and connect the upper ends of buckstays 16 along the front and rear of the structure. Skewback beams 13, which are connected to buckstays 16, also extend longitudinally of the frame and support skewbrick 14. Springing from the skewbricks 14 and extending transversely of the furnace is a sprung arch roof 15, built of basic refractory bricks 16 bonded together with joints staggered in a pattern which is hereinafter more fully described.

In a fully sprung arch of bonded basic bricks the rise of the roof, i.e., the number of inches the roof rises per foot of horizontal span between the skewbricks, should be not less than 2 1/4 inches. Contour control beams 17, which extend longitudinally of the furnace, rest on top of the roof. Hold-down jacks 18 preferably adjustable, extend radially of the arch and are connected to the cross-channels 11 and the beams 17.

In constructing the roof of my invention, conventional arch forms are erected in the furnace and the individual bricks are laid dry on the forms in rows, as shown in FIGURE 2, which extend longitudinally of the furnace, as for example rows A, B, C and D. One manner of erecting the roof is to lay the bricks starting at one end of the furnace and work toward the other end simultaneously from the front and back skewbacks to the crown. A convenient way of breaking the bond is to have the first brick 19 in alternate rows of bricks 50% wider in longitudinal cross-section than the bricks 16 which make up the remainder of the roof. By starting alternate rows in this manner with the oversize bricks 19 and then continuing the rows with the bricks 16, the joints extending transversely of the furnace between bricks in each row are offset with respect to the joints between bricks in the next adjacent rows, and the bricks are bonded together with joints staggered. After the brickwork has been completed, the contour control beams 17 are set substantially parallel on top of the roof. Jacks 18 are adjusted to hold the beams in position and restrain upward movement of the roof. The arch forms are dismantled and removed from the furnace which is then slowly brought up to temperature and placed in operation according to the usual practice.

At times, particularly on furnaces which have warped steelwork and which have the front and rear walls out of line, it has been found convenient to modify the construction described above, as shown in FIGURE 3. The erection of the roof proceeds, as already described, from the skewbrick to the crown on the roof. At the crown, for the full length of the roof, a key section 20 is installed by means of which the roof is tightly wedged together at the upper surface. Key section 20 is made up of key bricks 21 arranged in rows extending transversely of the furnace, as for example, rows X, Y and Z as shown in FIGURE 3. The width of key section 20 is a matter of construction, which is determined by numerous factors including non-alignment which may exist between the front and rear walls of a furnace, and variations which exist in the size of the bricks 16 and 19 that make up the remainder of the roof. As those skilled in the art know,
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Key bricks are made in standard sizes with various standard tapers. The number of key bricks 21, which make up the separate rows, such as rows X, Y and Z of the key section 20, may be a matter of design, but usually varies according to the size and taper of the key bricks 21 required to obtain the desired degree of tightness in the roof 15.

Naturally, in the roof of my invention the bricks must be laid up tightly, and provision must be made for thermal expansion of the refractory. Methods of compensating for thermal expansion are, of course, well known to those skilled in the art and include the use of insulating board spacers, asbestos spacers, etc. When the roof of my Invention is made with unlated basic bricks expansion allowance of between approximately .5% and 1.75% of the total arc of the roof should be provided at spaced intervals thereof between the rows of basic bricks. Contrary to the accepted way of providing expansion allowance in a basic roof, i.e., near the hot face only, the expansion allowance in such a roof should extend approximately the full thickness, i.e., at least 75% of the thickness, of the roof, and extend from the hot face toward the cold face. Thin sheets of insulation should be spaced between bricks about every foot across the arc of one roof to provide the desired amount of expansion allowance. Very thin spacers could be inserted in every brick joint, but this arrangement is somewhat impractical. Longitudinal expansion allowance should also be incorporated into the roof in a similar manner and should preferably be governed by the same specifications, i.e., between approximately .5% and 1.75%, but, as is well known to those skilled in the art, the provisions for longitudinal expansion of a furnace roof are not as critical as those for expansion in a transverse direction across the arch.

The expansion allowance incorporated into a roof of this type and made with metal encased basic bricks can not be specified as accurately as that for a roof of unlated basic bricks. In addition to the expansion allowance of the refractory, the method of encasing the bricks, the thickness of the metal casing and the magnesium oxide (MgO) content of the bricks must all be taken into consideration when the expansion allowance is determined for a basic roof made with metal encased bricks. Different manufacturers use different thickness metal to encase their bricks, and the methods of applying the casing to the refractory are not standard. In addition, less expansion allowance must be incorporated into a roof with bricks having a high magnesium oxide content than for a roof with bricks having a lower magnesium oxide content. Basic bricks with a high magnesium oxide content can absorb more iron oxide from the steel of their casings as they oxidize than can bricks with a lower magnesium oxide content. Preferably a roof of metal encased basic bricks constructed in accordance with my invention should have an expansion allowance of between approximately 0% and 2% of the total arc of the roof depending upon the several features, described above, of the particular metal encased bricks that are used.

In a specific embodiment of this invention, a sprung arch roof roof was constructed of metal encased burned chrome-magnesia bricks. A hot face expansion allowance was incorporated in each brick by the manufacturer. This allowance took the form of a small tapered slightly raised surface, approximately .020" high, at the hot face of one of the plates of the metal casing. Roof bricks 21 and 22 were used to start alternate rows, were 3" x 4 1/2" wedges; and key bricks 21 were various sizes, available from the standard selection of key shapes produced by refractory manufacturers, as required for tightly keying the roof. Contour control beams were placed on the roof and set in place by both forms were dismantled on the roof, and set in place by both forms were removed, and the furnace was slowly brought up to temperature and placed in operation. The A.I.S.I. Unit Roof Life of this roof, that is, the number of heats ob-
5. The metallurgical furnace roof of claim 4 in which said arch has a rise of not less than approximately 2\(\frac{1}{4}\) inches per foot of span.

6. The metallurgical furnace roof of claim 4 in which there are provided expansion means equal to between approximately 0.5% and 1.75% of the total arc of said arch at spaced intervals thereof between said rows of basic bricks.

7. The metallurgical furnace roof of claim 6 in which the expansion means provided extends approximately the full thickness of the roof and extends from the hot face toward the cold face thereof.

8. In a metallurgical furnace having buckstays spaced along the front and back thereof

(a) an overhead framework secured to said buckstays and spanning the roof transversely of the furnace,
(b) a sprung arch consisting of basic bricks extending transversely of the furnace,
(c) fixed skewbacks at opposite ends of said arch,
(d) rows of said basic bricks extending longitudinally of the furnace and comprising a construction wherein the joints between bricks in each row are offset with respect to the joints between bricks in the next adjacent rows,
(e) arch contour control means on said roof,
(f) means securing said arch contour control means to the overhead framework.

9. The metallurgical furnace roof of claim 8 in which the bricks are burned, uncased high strength basic bricks.

10. The metallurgical furnace roof of claim 9 in which said arch has a rise of not less than approximately 2\(\frac{1}{4}\) inches per foot of span.

11. The metallurgical furnace roof of claim 9 in which there are provided expansion means equal to between approximately 0.5% and 1.75% of the total arc of said arch at spaced intervals thereof between said rows of basic bricks.

12. The metallurgical furnace roof of claim 11 in which the expansion means provided extends approximately the full thickness of the roof.

13. In a metallurgical furnace having buckstays spaced along the front and back thereof

(a) an overhead framework secured to said buckstays and spanning the roof,
(b) a sprung arch consisting of high strength burned, uncased basic bricks and extending transversely of the furnace,
(c) said arch having a rise of not less than approximately 2\(\frac{1}{4}\) inches per foot of span,
(d) fixed skewbacks at opposite ends of said arch,
(e) rows of said basic bricks extending longitudinally of the furnace and comprising a construction wherein the joints between bricks in each row are offset with respect to the joints between bricks in the next adjacent rows,
(f) expansion means equal to between approximately 0.5% and 1.75% of the total arc of said arch at spaced intervals thereof between said row of basic bricks and extending approximately the full thickness of the roof,
(g) arch contour control means on said roof, and
(h) means securing said arch contour control means to the overhead framework.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,387,575

June 11, 1968

Ralph C. Padfield

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading to the printed specification, lines 4 and 5, "assignor to Bethlehem Steel Company, a corporation of Pennsylvania" should read -- assignor, by mesne assignments, to Bethlehem Steel Corporation, a corporation of Delaware --.

Signed and sealed this 18th day of November 1969.

(Seal)

Attest:
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