This invention relates to a refractory lining structure for a rotary kiln, and more particularly to a lining structure including both refractory bricks and insulating refractory material. The latter is disposed between the refractory bricks and the cylindrical metal shell of the kiln.

Rotary kilns desirably are provided with refractory linings which are as durable as possible for the reason that closing down a kiln for repair or replacement of the lining is highly uneconomical. It, therefore, is essential that the refractory bricks and insulating material be securely firmly in position so as to prevent damaging relative movement with the cylindrical shell and each other.

The prior art kiln linings commonly used are expensive to install and subject to frequent repair and replacement. Briefly described, the conventional prior kiln lining involves first the application of insulating material on the lower portion of the shell interior, and thereafter loosely installing the refractory bricks on the insulating material. This lining portion then is shored in place temporarily with framing and jacks, and thereafter the kiln is rotated sufficiently to install the remainder of the lining. Before the shoring is removed, steel plates are driven between the bricks to wedge the bricks together tightly in the cylindrical shell. The forces developed by the wedging procedure hold the bricks in place.

The aforesaid wedging forces exert radially outward pressures of high magnitude between the bricks and insulating material, and these pressures tend to compress the insulating material, thereby loosening the entire lining somewhat. As the kiln is rotated in use, relative movement occurs between bricks and insulating material and between insulating material and shell, thereby imposing strains on the insulating material leading toward loss of insulating value and subsequent disintegration. The loosening of the lining increases, and shortly reaches the point where the insulating material dusts out and the bricks drop out, requiring the installation of a new lining.

One object of this invention, therefore, is to provide a lining wherein each refractory brick is supported individually in a manner whereby it may not move inwardly or outwardly of the kiln, or rotationally relative to the shell. With this arrangement, the refractory insulating material lying in the annular space between the brick lining and the shell is not subjected to stresses which lead to loss of insulating value and subsequent disintegration.

Another object of the invention is to provide a refractory lining structure for a rotary kiln which eliminates the need for shoring during installation, and wherein the use of wedging is avoided.

Still another object of the invention is to provide a refractory lining structure for a rotary kiln which may be installed relatively rapidly, and which will have a long useful life.

Another and more detailed object is to provide brick holders arranged in a plurality of axially spaced rings on the interior of the kiln shell. A ring of brick holders provides a pair of more or less continuous, oppositely extending flanges in spaced relation from the shell. Bricks of the lining engage these flanges in clamping manner and are thereby prevented from moving inwardly or outwardly, or rotationally, with respect to the shell.

Other objects, advantages and details of the invention will be apparent as the description proceeds, reference being had to the accompanying drawings wherein one form of the invention is shown. It will be understood that the description and drawings are exemplary only, and that the scope of the invention is to be measured by the appended claims.

In the drawings:

FIG. 1 is a transverse sectional view through a rotary kiln having a refractory lining structure in accordance with the invention, only representative portions of the brick and brick holders being shown in detail, it being understood that the illustrated portions are continuous throughout the circumference of the kiln.

FIG. 2 is an enlarged fragmentary sectional view on line 2—2 of FIG. 1.

FIG. 3 is a fragmentary elevational view on line 3—3 of FIG. 2 showing the preferred staggered relation of the bricks in the lining.

FIG. 4 is an enlarged view of three brick holders in assembled relation on a portion of the kiln shell.

FIG. 5 is a top plan view of the assembled brick holders taken on line 5—5 of FIG. 4, the securing studs omitted.

FIG. 6 is a bottom view of the assembled brick holders taken on line 6—6 of FIG. 4, the securing studs and nuts omitted.

FIG. 7 is an enlarged sectional view on line 7—7 of FIG. 4 showing the relationship between the illustrated brick holder and added refractory bricks and insulating material.

FIG. 8 is an enlarged sectional view on line 8—8 of FIG. 4 showing the relationship between the illustrated brick holder and added refractory bricks and insulating material.

Referring to FIG. 1 of the drawings, rotary kiln 10 there shown in transverse cross section includes a cylindrical metallic shell 11. The mechanism for imparting rotary motion to kiln 10 may be conventional and therefore is not shown. The kiln axis may be horizontal or inclined at an angle with the horizontal, both conventional aspects of a rotary kiln and therefore not illustrated.

The lining structure includes axially spaced rings of brick holders generally designated 15 in FIGS. 1 and 2. The brick holders in each ring, in the form of the invention shown, are of two types which alternate with each other around the inner periphery of shell 11.

One type of brick holder, designated 16 in FIGS. 4—7 and hereinafter sometimes called alternate brick holder, is secured to the inner surface of shell 11. As shown in FIGS. 4 and 7, threaded studs 17 are welded or otherwise suitably mounted on the shell interior. Brick holders 16 fitting over the studs 17 and being secured in place by nuts 18 applied to the studs.

As best shown in enlarged FIG. 7, alternate brick holder 16 is generally U-shaped or channel shaped in cross section. The free ends of the channel legs have oppositely directed arcuate flanges 20 and 21 located in spaced relation with shell 11.

Intermediate brick holders 25 (FIGS. 4—6 and 8) are supported and fixed in position by alternate brick holders 16. As best shown in FIG. 8, intermediate brick holder 25 is T-shaped in cross section, the T head 26 being remote from shell 11. The marginal portions of T head 26 constitute oppositely directed arcuate flanges 28 and 29 which are aligned with the flanges 20 and 21 of alternate brick holders 16.

Each ring of alternate brick holders 16 and intermediate brick holders 25, therefore, provides a pair of oppositely directed flanges which are spaced inwardly of shell 11 and which form substantially continuous circular bands. As will be seen, refractory bricks are clamped on these continuous flanges and are held thereby against inward and outward movement.

Referring to FIGS. 4—6, intermediate brick holders 25
have an interlocked and detachable relationship with secured alternate brick holders 16. The construction of the two types of brick holders is such that the positioning of the alternate brick holders is not critical insofar as intermediate brick holders 25 are concerned.

Referring to the right-hand end of the intermediate holder shown in FIG. 4, central upstanding rib 30 is cut away at 31 to receive the left-hand end of flange 16. The construction of the two types of brick holders is such that the positioning of the alternate brick holders is not critical insofar as intermediate brick holders 25 are concerned.

Flanges 23 and 29 at the right-hand end of T head 26 are relieved, thereby providing a tongue 32 which underlies web 33 of brick holder 16. Thus, the right-hand end of intermediate brick holder 25 is restrained against both inward and outward movement with respect to shell 11.

The left-hand end of upstanding rib 30 of intermediate brick holder 25 likewise is cut away forming a slot at 35 to receive the right-hand end of adjacent brick holder 16. A plate 36 having downwardly extending teeth 37 (FIG. 4) is secured to the top of the slot at the left-hand end of brick holder 25. Also, the left-hand end of flange 28 and an adjacent portion of the T head 26 are relieved as shown at 38 (FIGS. 5 and 6) to permit assembly and disassembly of brick holder 25 and brick holder 16.

The right-hand end of each illustrated alternate brick holder 16 has flange 21 relieved at 40, also to permit assembly of intermediate brick holder 25. Further, the right-hand end of the web of brick holder 16 has an upstanding tooth 42 adapted to engage one or more of the teeth 37 on plate 36 of intermediate brick holder 25.

Brick holder 25 thus has a flexible relationship with the brick holder 16 which compensates amply for irregularities in the positioning of the threaded studs 17 that secure brick holder 16 in position. The size and flexibility of the illustrated brick holders are such that kilns of all reasonable diameters will receive the brick holders without requiring a final brick holder of regular size to close a ring.

The refractory bricks used in the illustrated lining are of three different sizes and shapes. In each case, the opposed sides that engage adjacent bricks in the same brick ring may be slightly tapered inwardly from the outer end to the inner end so the bricks will have uniform engagement from end to end when installed in a circular ring. Thus, the sides of the bricks that taper inwardly are the sides shown in profile in reduced FIG. 1 where the slight taper is not readily apparent.

In other respects, the refractory bricks used in the illustrated lining are generally the same as the brick shown in FIG. 2 of Hossein U.S. Patent No. 3,132,447. The brick is generally rectangular in transverse cross section, and all four sides have alternate ribs and grooves. The ribs and grooves on one pair of opposed sides are in alignment with each other, while the ribs and grooves on the other pair of opposed sides are in staggered relation with each other, the latter ribs and grooves being somewhat shallower in depth than the former.

4) Referring to FIGS. 2 and 3, the three bricks of different size and shape are respectively designated 45, 46 and 47. The brick sides shown in profile in FIG. 2 are generally parallel, apart from the ribs and grooves. The alternate two sides not shown in FIG. 2 are the sides having the aforesaid inward taper and the shallower ribs and grooves. Bricks 46 and 47, as shown, are equal in length, while brick 45 is somewhat shorter, thereby providing a smooth cylindrical surface on the lining interior.

5) Bricks 45 and 46 which engage each other and the flanges 20, 21, 28 and 29 of brick holders 16 and 25 are shown in enlarged FIGS. 7 and 8.

6) Bricks 45 are arranged in first rings of brick inwardly aligned with the several rings of brick holders 16 and 25 as shown in FIGS. 2, 7 and 8. Interlocking ribs 50 and 51 at the outer ends of the sides of bricks 45 parallel to flanges 20, 21, 28 and 29 are of reduced length, compared with the other ribs on those sides, to accommodate the thickness of the brick holder flanges. The outer ends of bricks 45 abut the flanges on the flange surfaces facing away from shell 11.

7) Bricks 46 have ribs 54 and 55 at the outer ends of the opposed sides which face the brick holders, and one of these ribs abuts and engages a flange on the flange surface facing shell 11, the remaining ribs and grooves on that brick side interlocking with the ribs and grooves of abutting bricks 45 in a first brick ring. Thus, adjacent bricks 45 and 46 in adjoining rings are interlocked with each other and clamped to a brick holder flange, securing all the bricks against both inward and outward movement.

It is apparent from the foregoing that each ring of brick holders 16 and 25 is engaged by a first ring of brick 45 and by second and third rings of brick 46, the first brick ring located between the other two brick rings.

8) The axial spacing of the brick holder rings and the brick widths in axial direction of the kiln are such in the illustrated lining that space exists to accommodate a ring of filler bricks 47 between rings of brick 46, as shown in FIGS. 2 and 3. Filler bricks 47 differ from bricks 46 in that the outer ends of the parallel sides are provided with grooves rather than ribs, such grooves, of course, receiving the outer ribs of interfitting bricks 46.

9) Conversely, the inner ends of the parallel sides of filler bricks 47 have ribs that interfit with complementary grooves at the inner ends of the bricks 46, all as shown in FIG. 2. Bricks 47, of course, are not held directly by brick holders 16 and 25, but rather are held in position against inward and outward movement by interlocking relation with bricks 46 which in turn are held directly by the brick holders.

10) Insulating refractory material 60 of desired type occupies the space between the outer ends of bricks 46 and 47 and shell 11. It also occupies the space within brick holders 25 and shell 11 and the space between brick holders 16 and 25, all as shown in FIGS. 2, 7 and 8. Insulating refractory material of castable type has been found particularly satisfactory for the lining of the invention.

11) Referring to FIG. 2, an end of the kiln is finished by means of an angle iron ring 65 secured to shell 11 by suitable securing means 66. Flange 67 of angle iron ring 65 desirably has a circular rib 68, shown in cross section in FIG. 2, which is received within a groove in endmost bricks 47. The flange 67, of course, holds the bricks 47 in interlocked relation with bricks 46, while rib 65 cooperates in supporting the bricks 47.

12) When the bricks in adjacent rings are staggered circumferentially as shown in FIG. 3, each brick is interlocked with two bricks in each adjacent brick ring. This feature, of course, imparts increased rigidity and durability to the over-all lining.

13) The illustrated brick holders 16 and 25 and the associated bricks are of such size that each alternate anchored brick holder 16 engages three bricks in a ring of bricks and each intermediate brick holder 25 engages four bricks in a ring of bricks (FIG. 1). Each ring of brick holders, as previously mentioned, engages with three rings of bricks.

14) As further shown in FIG. 1, the illustrated bricks in a ring have ribs and grooves on the sides there shown in profile, these ribs and grooves in staggered relation on opposite sides of a brick and interlocking with the sides of other bricks in the ring. The interlocking on all four brick sides, of course, enhances the sealing characteristic of the lining, the rigidity and durability.

The installation of the lining structure of the invention is believed apparent from the foregoing description. Briefly stated, the position points for the studs 17 first are marked on the interior of shell 11. Studs 17 all may be installed initially, or as the work progresses.

The insulating refractory material 60, refractory bricks 45, 46 and 47 and the brick holders 16 and 25 are installed in the lower 180 degrees of shell 11 for the full axial length of the shell. Each refractory brick prior to
installation may be dipped in an air set cement to improve the seal at the joints between adjacent bricks. Thereafter, shell 11 may be rotated through an angle, for example 45 degrees, and the components are installed from the lower edge of the completed work up to the level of the kiln axis. Next, the shell further may be rotated as necessary to complete the installation. Finally, the ends of the kiln are finished by the application of angle iron rings 65. Alternately, the entire lining may be installed without rotating the shell in the step by step manner suggested above, if desired. The various components so interlock that the bricks, brick holders and insulating material easily can be installed in overhead position.

From the above description it is thought that the construction and advantages of this invention will be readily apparent to those skilled in the art. Various changes in detail may be made without departing from the spirit or losing the advantages of the invention.

Having thus described the invention, what is claimed as new and desired to secure by Letters Patent is:

1. Refractory lining structure for a rotary kiln having a cylindrical metallic shell, comprising:
   axially spaced rings of brick holders secured to the inner surface of said metallic shell, each ring including a plurality of brick holders having oppositely directed flanges spaced from said shell; and refractory bricks secured to said brick holder flanges and interlocked with each other forming a refractory lining fixed against both inward and outward movement and rotational movement relative to said shell, said bricks having interlocking ribs and grooves on the sides thereof facing the kiln ends and including first rings of bricks inwardly aligned with the rings of brick holders, ribs at the outer ends of the bricks in said first rings engaging said brick holder flanges on the flange surfaces facing away from said shell, and second and third rings of bricks on opposite sides of said first brick rings, ribs at the outer ends of the bricks in said second and third rings engag-

2. The lining structure of claim 1 with the addition of insulating refractory material filling the annular space between said shell and said refractory bricks.

3. The lining structure of claim 1 wherein the bricks in adjacent rings are staggered circumferentially whereby each brick is interlocked with two bricks in each adjacent ring.

4. The lining structure of claim 1 wherein alternate brick holders in each ring are secured to said shell and the intermediate brick holders in each ring engage and are detachably supported by said alternate brick holders.

5. The lining structure of claim 4 wherein said alternate brick holders are generally U-shaped in cross section and said intermediate brick holders are generally T-shaped in cross section.

6. The lining structure of claim 4 wherein each alternate brick holder engages 3 bricks in a ring of bricks and each intermediate brick holder engages 4 bricks in a ring of bricks.

7. The lining structure of claim 1 wherein the bricks in each ring of bricks have interlocking ribs and grooves on the sides abutting other bricks in said ring.

References Cited

UNITED STATES PATENTS

2,854,842 10/1958 Hossein et al. ------- 265--46 XR
2,895,725 7/1959 Anderson -------------- 263--33
2,987,856 6/1961 Longenecker ---------- 263--46
3,112,921 12/1963 Wicken --------------- 263--33 XR
3,132,447 5/1964 Hossein --------------- 110--99 XR
3,220,546 7/1967 Bryan ---------------- 110--99 XR

FREDERICK L. MATTESON, Jr., Primary Examiner.

A. D. HERRMANN, Assistant Examiner.