ABSTRACT OF THE DISCLOSURE

A novel insulating structure for use between the steel shell and the internal refractory lining of a metallurgical furnace comprises an insulating means for engagement with the refractory lining to resist the transfer of heat to the steel shell and a stress absorbing means for engagement with the steel shell for resisting the formation and the transfer of stresses due to the thermal expansion of the refractory lining.

BACKGROUND OF THE INVENTION

This invention relates to stoves for use with a blast furnace, and more particularly, to an improved insulating structure internally disposed within the stove.

Conventionally, blast furnace stoves are refractory-lined heat regenerators enclosed within a circular steel shell with a flat bottom and a dome-shaped top; the conventional size of a modern stove is 28 feet in diameter and 18 feet in height from the bottom of the stove to the top of its dome. The function of the blast furnace stove is to preheat large volumes of air to temperatures ranging from 1000 to 2000°F before admission into the blast furnace. Essentially, a stove comprises two major compartments; the first being the combustion chamber which is a vertical passageway extending from the bottom of the stove to the bottom of the dome, and the second being the checkerwork chamber similarly extending from the bottom of the stove to the bottom of the dome comprising a heat regenerative system of a multiplicity of checker bricks situated therein. The above description refers to a two-pass design which is most prevalent today.

Heretofore, the cross-section of a typical two-pass blast furnace stove comprised (1) a steel shell, (2) an insulating block lining disposed adjacent to the inside surface of the steel shell, and (3) a refractory brick lining disposed adjacent to the insulating block lining. Frequently, the refractory brick lining was exposed to excessive temperatures, as high as 2600°F, especially in the upper region of the stove near the dome-shaped top.

Because of the thermal expansion of the refractory lining caused by the high operating temperatures of the stove, a combination of mechanical stresses were created, which stresses caused failures in the steel shell.

The present invention, however, includes features and advantages not heretofore known in the art which resist the formation and transfer of stresses as well as resist the transfer of heat to the steel shell, especially where blast furnace stoves are designed for higher hot blast temperatures.

SUMMARY OF THE INVENTION

According to the invention a thermal insulating structure for use with a metallurgical furnace having a steel shell and having an internal refractory lining comprises an insulating means for engagement with the refractory lining to the steel shell and a novel stress absorbing means for engagement with the steel shell and the insulating means for resisting the formation and transfer of stresses to the steel shell when the stresses are caused by the thermal expansion of the refractory lining.

For a further understanding of the invention and for advantages and features thereof, reference is made to the accompanied description and drawings referred to herein.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a simplified schematic elevational view of a blast furnace stove, illustrating the refractory and insulating linings; and

FIG. 2 is a sectional, isometric view illustrating the cross section of a typical stove in the prior art; and

FIG. 3 is a sectional, isometric view illustrating in greater detail the novel structure of this invention.

DETAILED DESCRIPTION

FIG. 1 illustrates a conventional two-pass type of blast furnace stove 11 comprising a steel shell 13, a refractory lining 15, a novel insulating lining 17 having an insulating means 19 and a stress absorbing means 21, a bottom plate 23 contiguous with the steel shell 13, and a domed shell portion 25 at the top of the stove 11.

Other features of the blast furnace stove include a refractory concrete base 27, a conventional combustion chamber 29 and a checker work chamber 31 delineated by a breast wall 33 which is contiguous with the refractory lining 15, and a conduit 35 leading from the combustion chamber 29 to the hot blast main (not shown) connecting the stove 11 to the blast furnace proper (not shown). It is noteworthy to the drawings in FIG. 1 is simplified and only those elements of the blast furnace essential for the description of this invention have been included; those skilled in the art should consult a suitable manual for a more detailed illustration of the blast furnace stove.

As previously indicated, the essential function of the blast furnace stove is to preheat tremendous volumes of air before their admission to the blast furnace for combustion with the burden in the blast furnace. The operation of a two-pass stove includes passing upwardly a combustible gas through the combustion chamber 29 wherein combustion of the gas occurs and downwardly through the checker work chamber 31, whereby the brick work within the checker work chamber 31, acting as a heat regenerator, absorbs heat from the combustion of the gases. To heat the air for the blast furnace, large volumes of air are subsequently passed countercurrently upwardly through the checker work chamber 31, wherein the air is heated to temperatures ranging from 1000°F to 2000°F, and downward through the combustion chamber 29 and into the hot blast main (not shown) by the conduit 35. Conventionally, three blast furnace stoves are used per one blast furnace where at any one time one stove is preheating the volumes of air for passage into the blast furnace, and the other two stoves are being heated by combustible gases to impart heat to the checker work within the checker work chamber 31. Each stove is heated for a period of two to four hours and is individually used to preheat the air for the blast furnace from 1 to 2 hours.

The steel shell 13 in FIG. 1 is fashioned into a cylindrical shell having a flat bottom plate 23 welded thereto and a dome top 25 positioned on the top of the cylindrical shell, the average diameter of a stove being 28 feet and the average height being 125 feet. The type and thickness of steel plates comprising this steel shell 13, of course, varies according to the relevant strength requirements of this steel shell 13. The shell 13, the bottom plate 23, and the other joints of the stove 11 must be completely
sealed by suitable welding to prevent the combustible gases and the products of combustion within the stove from passing into the atmosphere, a feature essential for safe operation.

The refractory lining 15 is internally disposed within the stove 11 to protect the steel shell 13 from high operating temperatures and to increase the thermal efficiency of the stove 11 by positioning within the interior of the stove refractory bricks in a cylindrical column, matching the general contour of the stove 11. The refractory lining 15 extends from the refractory concrete pad 27 at the bottom of the dome 25 and is conventionally composed of a high grade fire brick usually comprising a high alumina content, although some designers prefer a semi-silica brick. Those skilled in the art anticipate a refractory lining life of 15-20 years before it is necessary to reline the stove with a new refractory lining. Quite often it is necessary to replace the upper zone of the refractory lining 15 of the stove near the dome 25 because of the excessive temperatures in this region, sometimes as high as 2600° F.

Heretofore, stoves were lined with insulating and refractory materials as shown in FIG. 2, illustrating the prior art. The insulating lining 19 interposed between the steel shell 13 and the refractory lining 15 further protected the shell 13 from the high operating temperatures of the stove 11 and also improved the thermal efficiency of the stove 11. The material of which this insulating lining 19 was conventionally composed possessed a low thermal conductivity and high compressive strength at temperatures ranging from ambient temperatures to approximately 1900° F. Even with the insulating lining 19, temperatures of approximately 250° F were recorded on the outside face of the shell 13. The problems, however, generally related to the radial and axial expansion of the refractory lining 15 which compressed the insulating lining 19 between the rigid steel shell 13 and the refractory lining 15. A combination of radial and axial stresses resulting therefrom were imposed on the steel shell 13. The radial stresses resulted from several causes: (1) the expansion of the refractory lining 15 and to a lesser extent the tendency of the insulating lining 19 to expand; (2) the internal gas pressure of the stove 11; and (3) the thermal differentials across the various linings especially at the beginning of the operation of the stove 11. The axial stresses resulted from other causes: (1) the dead load of the various lining; and (2) the resistance of the vertical expansion of the insulating lining 19 by the coefficient of friction between the insulating lining 19 and the steel shell 13.

Stresses caused by the radial and axial expansion were heretofore accommodated by special design features. One such feature comprised the insertion of a flammable material, such as wood, between the refractory lining 15 and the insulating lining 19. When the newly installed lining was brought to operating temperatures the flammable material would disintegrate leaving a void into which the refractory lining 15 could expand, thereby reducing the probability of inducing stresses upon the steel shell 13.

In the last decade, however, the operating temperatures of blast furnace stoves have increased subjecting the refractory lining 15 to higher operating temperatures even greater expansion thereof. The simple insertion of a flammable material which disintegrates when the stove 11 is brought to operating temperatures does not effectively accommodate this additional expansion of the refractory lining. Nor is the insertion of a flammable refractory lining a laterality combined with the refractory lining 15 in the shell 13 caused by thermal expansion of the refractory lining 15.

This insulating structure 17 accordingly comprises one component, an insulating means 19 to resist temperature, and another component, a stress absorbing means 21 to resist stresses or to absorb stresses resulting from the thermal expansion of the refractory lining 15. The insulating means 19 coextensively engages the refractory lining 15 from the bottom of the stove at the refractory concrete pad 27 to the bottom of the dome 25 at the top of the stove 11. The insulating means 19 is a hard material in comparison to the material of the stress-absorbing means 21, which will be discussed hereinafter, and it is a mass composed of dense insulating inorganic substances. The insulating means 19 should preferably be composed of a material which has compressive strength, at temperatures ranging from ambient temperatures to approximately 1900°F. and low thermal conductivity to resist the transfer of heat.

The insulating means 19 may be composed, for example, of a calcined diatomaceous silica earth. Diatomaceous earth is a white friable, porous, chalk-like material of low density having amorphous structure. It is essentially composed of silica (SiO₂ x H₂O) where the chemical extends to create a larger void into which the refractory lining may expand practical because of the limitations on the size to which the total cross section of the stove may be reduced without a concomittant reduction in the thermal efficiency of the stove.
the trademark of the J-M Superex which is composed of a calcined diatomaceous silica blended with other insulating materials and bonded with asbestos fibers. This material is lightweight and has the unique combination of low conductivity and high thermal stability from temperatures ranging from ambient temperatures up to 1900° F.

On the other hand, the stress absorbing means 21 coextensively engages the steel shell 13 and the insulating means 19 from the bottom of the stove to the bottom of the dome 25 resisting the transfer of stresses to the steel shell 13 and also yielding to the expansion of the refractory lining 15. The stress absorbing means 21 is composed of a mass of resilient, readily compressible felted fibers and is considered to be a soft material having a soft face engaging the steel shell 13 in comparison to the insulating means 19 which is considered to be a hard material having a hard face engaging the refractory lining 15.

The stress absorbing means 21 must be composed of a material which is resilient and capable of deforming while the refractory lining expands and of resisting the transfer of combined stresses from the insulating means 19 to the steel shell 13.

The stress absorbing means 21 may conveniently be composed of a mass of resilient fibers comprising a felted blanket of mineral wool fibers. A typical felted mineral wool blanket is manufactured by Johns-Manville Company and is sold under the trademark of J-M Barrock Blankets. This material may be used under normal conditions for ambient temperatures up to 1000° F.

In addition, the stress absorbing means 21 may be composed of a mass of resilient fibers comprising a felted blanket of glass fibers as contrasted to the felted blanket of mineral wool fibers.

For convenience in installation, the insulating and the stress absorbing means 19, 21 may be bonded together by a suitable adhesive at an interface of the soft and hard material. The bonding agent for bonding the soft and hard material together may be an air setting bonding mortar composed of an inorganic relatively refractory adhesive. A typical adhesive is an admixture of clay with 4% to 12% by dry weight of an alkyl silicate.

In the manufacture of the molded material, the hard dense material, the insulating means 19, is molded to a desired shape. The soft resilient material, the stress absorbing means 21, is cut to a matching complementary size. The adhesive is applied to one face of the insulating means 19 and the one face of the stress absorbing means 21 is applied to the adhesive. When the adhesive sets these two materials are permanently and firmly bonded together.

The desired shape of the novel structure of this invention will, of course, depend on the contour of the steel shell 13. Usually the novel structure will be slightly curved substantially conforming to the curvature of the steel shell. Furthermore, the other dimensions of the novel structure will depend on several factors considering such problems as the ease of construction, installing, and handling the novel structure. The respective thicknesses of the insulating means 19 and the stress absorbing means 21 will depend on the type of metallurgical furnace, the design features, the thickness of the refractory brick lining 15, and the operating temperatures of such furnace. It has been found that in a blast furnace stove, having a diameter of 28 feet with a refractory lining of 18 inches and operating at approximately 2300° F., the insulating means 19, composed of the material earlier mentioned, should have a thickness of 2½ inches while the stress absorbing means 21, composed of the material earlier mentioned, should have a thickness of ½ inch to suitably protect the shell 13 from the heat and the combined stresses within the stove 11.

In the assembly of the various linings in the blast furnace stove the novel structure 17 is placed against an inside surface of the shell 13 with the stress absorbing means 21 against the shell 13. The refractory brick lining 15 is then placed adjacent the novel structure 17. It may be desirable to follow the old practice of inserting a flammable material, such as wood, between the new refractory lining 15 and the novel structure 17 of this invention so that the flammable material disintegrates when the stove 11 is brought to operating temperatures, leaving a void between the refractory brick lining 15 and the novel structure 17 into which the refractory lining 15 may expand.

Although the present invention has been described in conjunction with blast furnace stoves, the invention may be utilized with any type of metallurgical furnace where it is desirable to resist the conduction of heat from a refractory lining 15 to a steel shell 13 and to resist the transfer of stresses to the steel shell 13. This invention has particular application in a billet heating furnace of a continuous casting operation, which furnace is tubular in shape whose axis is substantially in a horizontal plane as contrasted to the blast furnace stove whose axis is substantially in a vertical direction.

The novel insulating structure 17 comprising the insulating means and the stress absorbing means solves a major problem which plagues any metallurgical furnace; namely, insulating the steel shell of the metallurgical furnace from the conduction of heat and resisting the formation and transfer of stresses to the steel shell. In addition, the novel structure hereinbefore described may be conveniently manufactured as a unit where the insulating means and the stress absorbing means are bonded together by a suitable inorganic adhesive material. Thus, the installation of the novel insulating structure is simple and may be conveniently adapted to the practical problems of lining a metallurgical furnace with refractory materials.

What is claimed is:

1. A molded thermal-insulating structure for a blast furnace stove whose outer surface is metal and whose inner surface is refractory brick comprising:
   (a) a soft material having a soft face for engagement with the surface of said metal;
   (b) a hard material having a hard face for engagement with the surface of said refractory brick; and
   (c) said soft and hard material being bonded at an inner face so that the soft material resists the formation and transfer of stresses to the steel shell caused by the thermal expansion of the refractory brick,

2. The molded thermal-insulating structure of claim 1 wherein said hard material is a dense mass of diatomaceous earth having asbestos fibers disposed randomly therethrough.

3. The molded thermal-insulating structure of claim 1 wherein said soft material is a mass of resilient fibers comprising a felted blanket of mineral wool fibers.

4. The molded thermal-insulating structure of claim 1 wherein said soft material is a mass of resilient fibers comprising a felted blanket of glass fibers.

5. An insulating material for use with a shell of a hot blast stove comprising:
   (a) a mass of resilient, readily compressible felted fibers;
   (b) a mass of dense insulating inorganic substances; and
   (c) a bonding agent for bonding said masses together whereby stresses imparted upon the dense mass due to thermal expansion are absorbed by the resilient mass.

6. The material of claim 5 wherein said masses are bonded together with an air-setting bonding mortar composed of an inorganic, relatively refractory adhesive.

7. A metallurgical furnace comprising:
   (a) a steel shell;
   (b) a refractory liner;
   (c) an insulating liner between the steel shell and the refractory liner;
   (d) said insulating liner comprising:
      (i) a mass of resilient, readily compressible felted
fiber composed of glass fibers engaging the steel shell;
(ii) a mass of dense insulating inorganic substance composed of diatomaceous earth reinforced with asbestos fibers randomly disposed therethrough engaging the refractory liner;
(iii) a bonding agent for bonding said masses together;
(e) whereby stresses imparted upon the dense mass due to thermal expansion are absorbed by the resilient mass.

8. The furnace of claim 7 wherein said furnace is a blast furnace stove cooperating by a conduit means with a blast furnace whereby gas is preheated in the stove before its admission into the blast furnace.

9. The blast furnace stove of claim 8 wherein said stove has a generally circular cross section and has a height greater than the diameter of the cross section.