COOLING ASSEMBLY FOR BLAST FURNACE SHELLS

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References Cited
UNITED STATES PATENTS
2,186,740 1/1940 Teeters........................................263/44
2,465,463 3/1949 Lindemuth..................................266/32 X
2,686,666 8/1954 Tau............................................266/32
2,805,851 9/1957 Becker et al..................................266/32
2,915,305 12/1959 Craig......................................266/25
3,034,776 5/1962 Hennenberger et al..........................263/44 X
3,193,272 7/1965 Kramer et al................................266/36 P

On the inside of a steel shell of a blast furnace there is provided a wall made of a refractory material having a high heat transfer characteristic, such as silicon carbide. Steel pipe loops for circulating a cooling medium are embedded in the wall and temperature sensing means within the refractory material check the temperature adjacent the pipe loops.

7 Claims, 2 Drawing Figures
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BACKGROUND OF THE INVENTION

For several years, with the increase in size of blast furnaces for iron manufacture, there has often been adopted a shell cooling structure in which stave-like cooling plates made of cast iron are arranged between the refractory lining material and the shell. The cooling plates may be manufactured by casting straight, hairpin-like or loop-shaped steel pipes into cast iron. The steel pipes upon casting come disadvantageously into contact with the hot molten iron so that they expand largely to deform and, at the same time, are carburized to become brittle while their partially uninterface contact with the cast iron makes their cooling effect non-uniform. In addition, since those defects are difficult either to detect from the outside or to repair, an involved technique is required for their manufacture. Consequently, accidents have often happened with the lining refractory material being reduced in strength owing to over heating or fall off occurring due to fusion and abrasion during operation of the furnace thereby uncovering the cooling plates so that the cooling plates, owing to over heating might be either cracked or burned off. As a counter-measure for this it has been attempted to use a high purity crystallizing alumina casting, having a considerably high heat transfer, heat resistance, and corrosion resistance as the lining refractory material and at the same time to provide a water spray cooler on the outside of the shell in consideration of any possible damages of the cooling plates. However, this attempt may be adopted only in a small-sized blast furnace of a remarkably high gas pressure owing to its very expensive refractory lining material.

SUMMARY OF THE INVENTION

The principal object is to obviate the above disadvantages. In accordance with the present invention, on the inside of a steel shell surrounding the portion of a blast furnace at which the inner pressure of the furnace is higher than the surrounding atmosphere there are arranged a plurality of sections of steel pipes, communicated to the exterior for circulating the cooling medium such as water, and temperature sensing means extending inwardly beyond the steel pipes, the pipes being embedded in a wall made of a rapidly heating and cooling-resistant and high heat transfer refractory material such as silicon carbide. Such a refractory material owing to its high heat transferability may be kept at a low temperature by circulating cooling water in the steel pipes embedded therein. The refractory material, although hot contents such as fused slag flow down along the inner surface thereof, never falls off through reduction in strength or fusion due to its overheating. The fused slag deposits easily on the refractory material consisting of silicon carbide and solidifies rapidly to produce a dense slag layer on the core surface of the refractory material. This layer effectively prevents a high pressure gas within the furnace from leaking out and improves the heat shielding performance of the blast furnace thereby minimizing its heat loss. The slag layer, which adheres closely to the refractory material held at a low temperature, neither fuses nor falls off, and serves to protect the refractory material. The refractory material, though subjected to a high temperature and a rapid cooling before and after deposition and solidification of the slag layer, is satisfactorily protected against them, and neither is cracked nor decreases its strength. The refractory material, if cracked, is carried by the cooling pipes embedded therein without falling off, and the crack may be covered with the slag layer whereby the high pressure gas within the furnace is prevented from leaking out. The water, which might leak from the cooling pipes due to defects in their material, would permeate into the relatively porous refractory material and evaporate there to lower the temperature of the vicinity. The temperature drop is sensed by means of any of the temperature sensing means embedded in the refractory material so that the pressure of the circulating water in the cooling pipes is reduced below the gas pressure within the furnace to prevent the leakage of water. The circulation of water may also be switched over from the defective cooling pipe to a reserve cooling pipe to continue the operation of the blast furnace. In this case the cooling pipe out of operation or the reserve cooling pipe serves to reinforce the refractory material and to improve the heat transfer.

The steel pipes for circulating cooling water according to the invention, which are not cast into hot molten iron as in the known stave-like cooling plates made of cast iron, neither deteriorates nor deforms. Since each cooling pipe may be made long in conformity with the dimensions of the blast furnaces, the number of connecting members for water inlet and outlet is reduced to decrease the circulating resistance of the cooling water. The double arrangement of the cooling pipes, one of which is reserved, facilitates a long continuous operation of the blast furnace. The reduction in number of the inlets and outlets for cooling water to be provided at the shell of a large-sized high pressure blast furnace increases the strength of the shell and reduces the number of sealing means for the inlets and outlets.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 is a vertical sectional view of a portion of a blast furnace, embodying the present invention, and illustrating the furnace in its initial brick-lined condition; and

FIG. 2 is a view similar to FIG. 1 illustrating the furnace after an extended period of operation in which the brick has been eroded away and replaced by a layer of slag.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the Figure, the reference numeral 1 denotes a portion of a thick steel plate shell of a blast furnace with a high inner pressure, on the inside of which is arranged a vertical loop 2 of steel pipe, for circulating cooling water, having a water inlet 2' and a water outlet 2". A horizontal loop 3 of steel pipe for circulating cooling water, which is arranged on the inside of the vertical pipe loop 2, is provided with a water inlet 3' and a water outlet 3". Temperature sensing units 4 extend inwardly beyond the horizontal pipe loop 3. The reference numeral 5 denotes a refractory material such as silicon carbide in which the pipe loops 2 and 3 are embedded. Fire clay bricks 6 are laid on the inside of the refractory material 5. The reference numeral 7 denotes a blast furnace slag layer which has deposited on the inner surface of the refractory material after the fire clay bricks fell off.

Upon assembly, the vertical pipe loop 2 and the horizontal pipe loop 3 are arranged in layers in the first furnace, and the temperature sensing units 4 are inserted therebetween. A refractory mortar 5 of silicon carbide is placed around the pipe loops 2, 3 and the temperature sensing units 4, and the fire clay bricks 6 are held against the inside of the refractory mortar 5. After the mortar 5 has solidified, the shell cooling assembly of the blast furnace is completed.

Upon operation of the blast furnace, cooling water from the inlet 3' is circulated in the horizontal pipe loop 3 to cool the refractory material 5 thereby preventing the reduction in strength of the fire clay bricks 6 due to overheating or the falling off thereof due to fusion and abrasion. Since the refractory material 5 surrounds the horizontal pipe loop 3 thoroughly, a satisfactory heat transfer at the contact surface therebetween may be obtained. The contact surface between the refractory material 5 and the fire clay bricks 6 is made larger as shown so that the heat transfer at this surface is high. The cooling effect of such cooling assembly is thus substantially the same as that of a prior cooling assembly made of stave-like cooling plates made of cast iron with cooling pipes cast therein and fire clay bricks lining inside of the plate. Even if a gap is formed between the refractory material 5 and the fire clay bricks 6 to impair the heat transfer so that any of the fire clay bricks 6 owing to overheating might fuse and fall off, the cooling pipe 3, covered with a thick layer of the refractory materi-
3,652,070 3 al 5, would not come into direct contact with hot contents of the blast furnace, for example, fused slag as in the case where stave-like cooling plates are lined with fire clay bricks. If the fused slag should come into contact with the refractory material 5, it would be rapidly cooled and solidify thereby forming a solid slag layer 7 which in turn protects the refractory material 5. The refractory material 5, which contains silicon carbide or silicon and whose surface is made course, is excellent in its adhesion to the fused slag. The slag layer 7 is highly airtight and remarkably effective as a lining for a high pressure blast furnace. The refractory material 5 stands rapid heating and cooling, and neither be cracks nor decreases in strength while the slag layer 7, which is satisfactorily cooled by the refractory material 5 without fusion or falling off, serves as a heat shield to reduce the heat loss of the furnace.

In case where the refractory material 5 is originally not lined with fire clay bricks 6, an airtight slag layer 7 may be easily produced by adhering fused slag within the furnace to the refractory material 5 and solidifying it. In this case the temperature of the refractory material 5 is sensed by means of the temperature sensing units 4 for either controlling the quantity of water to be circulated in the cooling pipe loop 3 or additionally circulating water in the cooling pipe loop 2 so that the degree of cooling of the refractory material is increased to promote the adhesion as well as the solidification of the fused slag.

If the cooling pipe 2 or 3, owing to defects in manufacture, should be cracked thereby allowing water in the cooling pipe to leak out, the water leaked out would permeate through the refractory material 5 and evaporate to cool the vicinity. The leakage of water, which has been sensed by means of any of the temperature sensing units 4, may be prevented either by lowering the pressure of the circulating water below the gas pressure within the blast furnace or by locally stopping the circulation of water and changing over from one cooling pipe to the other. The airtight layer of refractory material 5, the pressure and the temperature of water to be circulated in the pipe loop 2 or 3 may be selected in the order of 10 atm. and 180°C., respectively, so that steam is produced in the pipe 2 or 3. The pressure and the temperature may be of the order of 3 atm and 90°C., respectively, so that no steam is produced. In the former case, it is effective in reducing heat loss to provide a heat insulating refractory layer between the shell 1 and the refractory material 5.

As is clear from the foregoing, a cooling assembly for a blast furnace shell according to the invention, composed of a wall made of a refractory material having a high heat transfer coefficient and a layer of refractory material 2, 3 for circulating a cooling medium such as water embedded therein, may, owing to a slag layer formed on the inside thereof, improve the airtightness and the heat shielding performance so that the thickness of the lining and thus the weight of the furnace is reduced while the inner volume thereof is increased. If the adhesion of a fused slag to the refractory material 5 is superior to that of silicon carbide, the lower limit of the thermal conductivity of the refractory material may be raised up to several times as high as that of the lining 6 or 7, for example, 3-5 K.cal/m.h.°C.

1. A cooling assembly for a blast furnace, comprising a steel shell laterally enclosing and forming the lateral exterior surface of at least a portion of the blast furnace within which portion the pressure is higher than the atmospheric pressure on the outer surface of said shell, a layer of a high heat transfer refractory material on the inner surface of said shell, said refractory material being resistant to rapid heating and cooling and having an adhesion characteristic, to a fused slag, superior to that of silicon carbide, a plurality of steel pipe sections embedded in said layer of refractory material along the inner surface of said shell, means for connecting said steel pipe sections to at least one source of cooling medium located exteriorly of said shell for circulation of cooling medium through said pipe sections for control of the temperature of said layer of refractory material, and temperature sensing means positioned within said refractory material adjacent said pipe sections and extending inwardly beyond said pipe sections, for sensing the temperature within said refractory material adjacent and inwardly of the surfaces of said pipe sections, whereby cooling medium may be selectively circulated through said pipe sections in accordance with the temperature within said refractory material inwardly of said pipe sections as sensed by said sensing means to control the temperature within said refractory material to control the adhesion of fused slag thereto.

2. A cooling assembly for a blast furnace, as set forth in claim 1, wherein said steel pipe sections comprises at least one vertically extending loop and at least one horizontally extending loop, and said means for connecting said steel pipe sections to a cooling medium source comprising a separate cooling medium inlet and outlet for each of said loops.

3. A cooling assembly for a blast furnace, as set forth in claim 1, including fire clay bricks lining the inner surface of said refractory material within the blast furnace.

4. A cooling assembly for a blast furnace, as set forth in claim 3, wherein the surfaces of said fire clay bricks in contact with the surface of said refractory material are beveled for increasing the surface contact between said fire clay bricks and said refractory material.

5. A cooling assembly for a blast furnace, as set forth in claim 4, wherein the surfaces of said fire clay bricks in contact with said refractory material are beveled for increasing the contact area therebetween.

6. A cooling assembly for a blast furnace, comprising a steel shell enclosing and forming the exterior surface of at least a portion of the blast furnace within which the pressure is higher than the atmospheric pressure on the outer surface of said shell, a plurality of steel pipe sections located along the inner surface of said shell, means for connecting said steel pipe sections to a cooling medium source located exteriorly of said shell for circulating the cooling medium through said pipe sections, a layer of high heat transfer refractory material embedding said pipe sections within the blast furnace, said refractory material being resistant to rapid heating and cooling and having a refractory characteristic substantially similar to that of silicon carbide, and temperature sensing means positioned within said refractory material adjacent said pipe sections for sensing the temperature within said refractory material adjacent the surfaces of said pipe sections, said steel pipe sections comprising at least one vertically extending loop and at least one horizontally extending loop, and said means for connecting said steel pipe sections to a cooling medium source comprising a separate cooling medium inlet and outlet for each of said loops, said vertically extending loop of said steel pipe sections being located adjacent the inner surface of said steel shell and said horizontally extending loop of said steel pipe sections being located adjacent to and inwardly from said vertically extending loop, said temperature sensing means extending inwardly through said steel shell and between said loops to a point within said refractory material located inwardly from said horizontally extending loop.

7. A method of cooling a blast furnace comprising forming, on the interior surface of the shell of the blast furnace, a coating of a high heat transfer refractory material which is resistant to rapid heating and cooling and which has an adhesion characteristic to a fused slag superior to that of silicon carbide, circulating a cooling medium through a refractory material in a plurality of separate passages extending therethrough, sensing the temperature within the refractory material adjacent and inwardly of the passages for flow of cooling medium therethrough, and regulating the circulation of the cooling medium through the refractory material in response to the temperature sensed within the refractory material inwardly of the passage to control the adhesion of fused slag thereto.