Title: A COOLING PANEL FOR A FURNACE

Abstract: A fabricated cooling panel (1) for a furnace or a cupola comprises a metal, preferably steel, backing plate (2) to which is secured a metal, preferably copper, cooling pipe (3). The pipe (3) has at least one outwardly extending fin (4) that is integrally formed therewith. In a first embodiment, the fin (4) catches slag and debris which circulate in the interior of the furnace during use. Alternatively, in a second embodiment, fin (4) assists in anchoring a refractory layer (9), which is applied to the interior side of the backing plate (2) and in which the pipe (3) and its integral fin (4) is embedded. The panel is particularly suitable for use in the reducing atmospheres found inside blast furnaces and iron smelting furnaces.
A COOLING PANEL FOR A FURNACE

The present invention relates to a cooling panel for a furnace or a cupola and in particular to a panel which can be used to replace part of the cooling system of a blast furnace or an iron smelting furnace.

Furnaces such as blast furnaces and iron smelting furnaces are cooled to reduce the operating temperature of the refractory lining and hence to lower the rate of chemical attack and erosion on the lining and thereby extend its working life; to protect the structural integrity of the load-bearing parts of the furnace shell; and to permit the use of metal parts for items such as tuyeres and hot blast valves where it is not possible to use refractory materials. Conventionally, two methods are used for cooling furnaces, namely plate coolers and stave coolers.

A plate cooler is built into the refractory lining of the furnace and comprises a cast, high-purity, copper block which is machined to provide channels through which water can be circulated. Typically, the plate is around 100 mm thick and the water channels are arranged to provide a good heat transfer by keeping the water velocity high in critical areas. Such coolers can be relatively easily replaced during the life of a furnace from the exterior of the furnace and are usually fitted with a steel flange which can be welded directly to the furnace shell to make a gas-tight seal. However, disadvantages of plate coolers include the fact that they are expensive because they are cast from solid copper blocks. In addition, as they are machined to provide the cooling channels, the dimensions of the block are limited to the maximum size of block which can be machined, that is typically around 2.5 m and the channels must be spaced apart significantly to prevent weakening of the block. Also, the machining process produces a large quantity of copper waste.
In contrast, stave coolers are usually made from cast iron or copper and are fitted inside a furnace between the outer steel shell and the refractory lining to form a continuous layer which protects the shell. Embedded in the casting are a number of cooling pipes, which are made using formers during casting. Rows of refractory bricks may also be set into the hot face of the casting to improve abrasion resistance and to reduce the rate of heat absorption. Disadvantages of such stave coolers include the fact that each typically comprises a cast 2m x 2m block which is between 180 and 400 mm thick. Hence, they can each weigh up to 3 tonnes. Replacing a stave cooler is also difficult as they must be fitted from inside the furnace. As furnaces are never allowed to cool significantly when once in use, the furnace must be cooled slightly by switching off the blowers for a few days before lowering in new staves from the top of the furnace. There is, therefore, significant downtime in the operation of the furnace during this process.

The object of the present invention is to provide a cooling panel for a furnace which provides more effective cooling than the conventional cooling arrangements described above and which is more cost effective to manufacture and to fit than these conventional cooling arrangements.

According to the present invention there is provided a fabricated cooling panel for a furnace or a cupola comprising a metal backing plate to which has been secured a metal cooling pipe that has at least one outwardly extending fin integrally formed with the cooling pipe.

It will be appreciated that in the present invention, the cooling panel is made by fabrication rather than being cast. This has the advantage that unlike the prior art, no costly machining operations are required to form the conduits for
the cooling liquid. Instead, because the panel is fabricated, a plurality of interconnected cooling pipes can be arranged as required to link into the cooling water circuit of any particular portion of a blast furnace. This enables the cooling pipes to be arranged much more closely together than can the machined channels of the prior art, which results in more efficient cooling. Also, the backing plate can be made in any shape to fit into the shell of a furnace where required.

Preferably, the cooling pipe and integral fin are made of copper.

Preferably, the panel comprises a layer of refractory material on one side in which the cooling pipe is embedded.

Preferably also, the cooling pipe and integral fin are embedded in and covered by the refractory material

Preferably also, the refractory material comprises a refractory containing no calcium aluminate cement.

Preferably also, the refractory material comprises a cement-free refractory.

Advantageously, the refractory material comprises a non-aqueous binder. For example, the refractory material preferably comprises a colloidal silica bonded refractory material.

Preferably also, the thickness of the refractory layer is between 110 mm and 250 mm inclusive.

Preferably also, the cooling pipe and integral fin is made by extrusion.
Preferably also, the cooling pipe (3) has an outside diameter of at least 25 mm and a wall thickness of at least 10 mm. Advantageously, the cooling pipe has an outside diameter of 82.5 mm and a wall thickness between 12 mm and 15 mm inclusive.

Preferably also, the thickness of the backing plate is at least 10 mm and advantageously is between 16 mm and 20 mm inclusive.

Preferably also, the fin runs longitudinally along the length of the pipe.

Preferably also, the cooling pipe comprises two outwardly extending fins that are integrally formed therewith. Advantageously, the fins extend from the pipe symmetrically on its side opposite the backing plate at an angle of 60° to one another.

Preferably also, the cooling pipe is bonded to the backing plate by means of an interfacing pad. Preferably, the pad is welded both to the pipe and to the backing plate. Advantageously, the interfacing pad comprises an aluminium-bronze pad.

Preferably also, the backing plate comprises a steel backing plate. Alternatively, the backing plate comprises a copper clad steel panel.

Preferably also, the backing plate is curved to follow the contour of the shell of a furnace where the cooling panel is to be installed.

The present invention will now be described by way of example with reference to the accompanying drawings, in which:-
Fig. 1 is a front view of a blast furnace cooling panel according to the invention;

Fig. 2 is a cross-sectional view along with line II-II in Fig. 1.

Fig. 3 is a cross-sectional view similar to Fig. 2 but of a second embodiment of panel and to an enlarged scale; and

Figs. 4, 5, 6 and 7 are a front views similar to Fig. 1 but showing alternative arrangements of cooling pipes.

In Figs 1 and 2, a cooling panel 1 for a furnace is shown comprising a metal backing plate 2 to which is secured a metal cooling pipe 3. The pipe 3 has at least one outwardly extending fin 4 that is integrally formed therewith. The metal cooling pipe 3 can have any shape and in practice a plurality of interconnecting pipes 3, comprising straight lengths of pipe 3 interconnected by U-shaped elbows 4, are attached to the backing plate as shown in Fig 1 and Figs. 4 - 7. The pipes 3 are arranged over the surface of the plate 2 as desired to provide the required cooling effect and may form part of one or more separate water cooling circuits.

Figs. 1, 4 and 5 show panels 1 where the pipes 3 are all interconnected to provide a single cooling circuit but in Figs. 6 and 7 are shown panels each with pipes 5 and 6 defining two water circuits respectively and room for attachment of a further set of pipes 7 to form a third cooling circuit.

The panel 1 of the invention is intended to be fitted either directly to the interior of the shell of a blast furnace by attachment of the backing plate 2 to the shell or, more typically, to replace a damaged or over-heating area of the shell directly. In the latter case, the damaged area of
the shell is removed and a cooling panel according to the
invention fitted in its place, with its backing plate 2
replacing the removed area of the shell. It will be
appreciated that the backing plate 2 can be made in any shape
or size to accomplish this purpose and incorporate
appropriate attachment means around its edges to enable it to
be welded into position. Also, the cooling pipes 2 can be
provided in any configuration as desired to give the required
degree of cooling and to link into the existing water cooling
circuitry of the furnace. An additional advantage of this
arrangement is that the panel can be fitted from the outside
of the furnace.

The pipes 2 and integral fins 3 are made of copper by
extrusion. As the pipes 2 must withstand the harsh conditions
within the furnace, the cooling pipes have an outside
diameter of at least 25 mm and a wall thickness of at least
10 mm dependent on the overall dimensions and type of furnace
or cupola. More typically, however, the cooling pipes 2 have
an outside diameter of 82.5 mm and a wall thickness between
12 mm and 15 mm inclusive as required. These thicknesses have
been determined as those which provide the most efficient
cooling whilst still remaining sufficiently thick to
withstand operation within the furnace. Likewise, the
thickness of the backing plate is typically at least 10 mm
but more typically has a thickness between 16 mm and 20 mm
inclusive. The backing plate is usually made of steel or
stainless steel with a curvature appropriate to follow the
contour of the shell of the furnace where it is to be
installed. In some applications the backing plate 2 may
comprise a copper clad steel panel wherein a 4 mm copper
coating is hot rolled onto the inner surface of the panel 2.

In all cases, the pipes 3 and associated elbows 4 are
bonded to the backing plate 2 by means of an interfacing pad
8 (see Fig. 3). Advantageously, the interfacing pad 8
comprises an aluminium-bronze pad which is welded to the pipes 3 and elbows 3 before being welded to the backing plate 2.

The integrally extruded fin 4 of each pipe 3 runs longitudinally along the length of the pipe 3 and acts as a heat sink to assist in the conduction of heat away from surrounding region of the furnace and thereby assist in transmission of the heat to the cooling water circulating in the pipe 3. Preferably, each pipe 3 comprises two outwardly extending fins 4, as shown in Figs. 2 and 3, which extend from the pipe 3 symmetrically on its side opposite the backing plate 2 at an angle of 60° to one another.

In a first embodiment, as shown in Figs. 1 and 2, the fins 4 catch slag and debris which circulate in the interior of the furnace during use. This debris and slag settles in layers over the pipes 3 and the fins 4 and helps to protect them from the highly abrasive and chemically destructive atmosphere in the furnace.

In this regard, it should be appreciated that the atmosphere inside blast furnaces and iron smelting furnaces are reducing atmospheres which recover oxygen from the iron being smelted and are thus highly corrosive. This is in contrast to the oxidizing atmosphere which exists inside an electric arc furnace where oxygen is used to burn the fuel and remove carbon from the iron.

In a second embodiment of panel 1, as shown in Fig. 3, the pipes 3 and their integral fins 4 are embedded in and covered by a layer of refractory material 9 which is applied to the interior side of the backing plate 2. In this embodiment the refractory material 9 completely covers the pipes 3 and thereby protects them from the atmosphere of the furnace and in particular the corrosive reducing atmosphere.
The fins 4 assist in anchoring the refractory layer 9 and also assist in drawing heat from it for transmission to the cooling water circulating in the pipes 3.

Preferably, the refractory material is cement-free or contains no calcium aluminate cement. The reason for this is that most refractories utilize calcium aluminate cement (CAC) as the bonding material for holding the refractory aggregate together. The amount of CAC in the mix can vary from relatively low quantities to quantities of 10% or more, depending on manufacturer and the mix. The refractory materials and cement are mixed with water to a proper consistency and installed in place. The added water reacts with the CAC forming hydrated phases that provide low temperature bonding of the refractory materials. At low temperatures the CAC materials are very dense and have very low permeabilities. However, as the refractory is heated, the physical water is first driven off followed by the chemically bonded hydrated water. Because several hydration phases are present, complete dehydration occurs over a broad temperature range. As each hydration phase gives up its chemically bonded water, the bonding strength of the refractory decreases and its permeability and porosity increase until all water has been removed. Hence, such a refractory layer if used in a panel according to the invention would gradually break down and deteriorate in use.

To prevent such deterioration, the refractory layer 9 preferably comprises a non-aqueous binder, for example a colloidal silica bonded refractory material. If a colloidal silica binder, not water, is mixed with the dry refractory materials, setting additives also included in the mix cause the material to gel and set at a controlled rate. This gellation is due to a condensation reaction that involves the release of water. Unlike CAC bonding that involves the production of chemically bonded water, the colloidal silica
bonded material liberates chemically attached water. Thus the silica bonding involves the formation of a chemical bond that does not breakdown through dehydration as the material is heated. As a result, the refractory layer 9 is more persistent and shows minimum deterioration when in use within a furnace. Also, such a refractory layer 9 does not define capillaries or other passages which therefore, blocks the passage of corrosive and other harmful gases through the layer 9 and thereby protects the pipes 3 and the backing plate 2.

The thickness of the refractory layer can vary dependent on the cooling capability of the panel 1. This is dependent on the rate of water flow through the pipes 3 and on the spacing and arrangement of the pipes 3 on the panel. It is expected that the thickness of the refractory layer may vary between 110 mm and 250 mm dependent on the application. In all cases this results in a panel 1 which is considerably thinner than a conventional cooling panel or stave. In view of this, if cooling panels according to the invention are used throughout a blast or iron smelting furnace then the working volume of the furnace is increased, thus increasing its operating throughput and with a subsequent reduction in operating costs.

The optimum design of cooling panel is one which will satisfy the operating conditions that the furnace shell is retained at a temperature less than 100°C and the maximum temperature of the inner face of refractory layer 9 remains below 1000°C. Dependent on the particular operating conditions, size and design of the furnace in question, including the rates of water flow through its water cooling circuits, mathematical models can be constructed to emulate various designs of panel 1 having different thickness and arrangements of pipes 3 and with different refractory layer
thicknesses. The optimum configuration of panel 1 can then be decided on for the furnace in question prior to construction.
CLAIMS

1. A fabricated cooling panel (1) for a furnace or a cupola comprising a metal backing plate (2) to which has been secured a metal cooling pipe (3) that has at least one outwardly extending fin (4) integrally formed with the cooling pipe (3).

2. A panel as claimed in Claim 1, wherein the cooling pipe (3) and the integral fin (4) are made of copper.

3. A panel as claimed in Claim 1 or Claim 2, wherein the panel (1) comprises a layer of refractory material (9) on one side in which the cooling pipe (3) is embedded.

4. A panel as claimed in Claim 3, wherein the cooling pipe (3) is embedded in and covered by the layer of refractory material (9).

5. A panel as claimed in Claim 3 or Claim 4, wherein the refractory material (9) comprises a refractory containing no calcium aluminate cement.

6. A panel as claimed in any of Claims 3 to 5, wherein the refractory material (9) comprises a cement-free refractory.

7. A panel as claimed in any of Claims 3 to 5, wherein the refractory material (9) comprises a non-aqueous binder.

8. A panel as claimed in any of Claims 3 to 7, wherein the refractory material (9) comprises a colloidal silica bonded refractory material.
9. A panel as claimed in any one of Claims 3 to 8, wherein the thickness of the refractory layer (9) is between 110 mm and 250 mm inclusive.

10. A panel as claimed in any one of Claims 1 to 9, wherein the cooling pipe (3) and integral fin (4) is made by extrusion.

11. A panel as claimed in any one of Claims 1 to 10, wherein the cooling pipe (3) has an outside diameter of at least 25 mm and a wall thickness of at least 10 mm.

12. A panel as claimed in any one of Claims 1 to 10, wherein the cooling pipe (3) has an outside diameter of 82.5 mm and a wall thickness between 12 mm and 15 mm inclusive.

13. A panel as claimed in any one of Claims 1 to 12, wherein the thickness of the backing plate (2) is at least 10 mm.

14. A panel as claimed in any one of Claims 1 to 12, wherein the thickness of the backing plate (2) is between 16 mm and 20 mm inclusive.

15. A panel as claimed in any one of Claims 1 to 14, wherein the fin (4) runs longitudinally along the length of the pipe (3).

16. A panel as claimed in any one of Claims 1 to 15, wherein the cooling pipe (3) comprises two outwardly extending fins (4) that are integrally formed therewith.

17. A panel as claimed in Claim 16, wherein the fins (4) extend from the pipe (4) symmetrically on its side opposite the backing plate (1) at an angle of 60° to one another.
18. A panel as claimed in any one of Claims 1 to 17, wherein the cooling pipe (3) is bonded to the backing plate (2) by means of an interfacing pad (8).

19. A panel as claimed in Claim 18, wherein the interfacing pad (8) which is welded both to the pipe (3) and to the backing plate (2).

20. A panel as claimed in Claim 18 or Claim 19, wherein the interfacing pad (8) comprises an aluminium-bronze pad.

21. A panel as claimed in any one of Claims 1 to 20, wherein the backing plate (2) comprises a steel backing plate.

22. A panel as claimed in any one of Claims 1 to 20, wherein the backing plate (2) comprises a copper clad steel panel.

23. A panel as claimed in any one of Claims 1 to 22, wherein the backing plate (2) is curved to follow the contour of the shell of a furnace where the cooling panel (1) is to be installed.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IP 7 C21B/10 F27B1/24 F27D1/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IP 7 C21B F27B F27D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of box C.

Patient family members are listed in annex.

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Date of the actual completion of the international search: 18 September 2002
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INTERNATIONAL SEARCH REPORT

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