EVAPORATIVE COOLING APPARATUS FOR COOLING STAVE

Inventors: Takeo Yamada; Kazuo Kunioka; Shunichi Sugiyama; Toyokazu Teramoto, all of Yokohama, Japan

Assignee: Nippon Kokan Kabushiki Kaisha, Tokyo, Japan

Filed: Nov. 14, 1974

Appl. No.: 523,825

Foreign Application Priority Data
Nov. 19, 1973 Japan................................. 48-129146

U.S. Cl. ........................................ 266/32; 122/7 R
Int. Cl. ........................................ C21B 7/10
Field of Search 266/32, 43, 25; 122/7 R, 122/407, 489

References Cited
UNITED STATES PATENTS
3,818,870 6/1974 Andoniev et al. .............. 266/32 X

ABSTRACT

There is provided an evaporative cooling apparatus for a cooling stave comprising a steam separator, a downcomer, a cooling stave and a riser. The steam separator is provided with a steam inlet pipe for maintaining the water temperature in the steam separator at substantially the boiling point. The paths of the downcomer and the riser are interconnected by a circulation activating pipe. Steam is introduced into the circulation activating pipe through a circulation activating steam feed pipe connected to the former to cause the circulation of water through the downcomer, the circulation activating pipe, the riser and the steam separator, and the amount of steam supplied is suitably increased to cause the circulation of the cooling water at a temperature near the boiling point through the cooling tubes of the cooling stave. In this way, the occurrence of water hammering phenomenon under low heat load conditions is effectively prevented.

7 Claims, 2 Drawing Figures
FIG. 1
FIG. 2
1

EVAPORATIVE COOLING APPARATUS FOR COOLING STAVE

BACKGROUND OF THE INVENTION

Known evaporative cooling apparatus of the above type comprise, as for example illustrated in FIG. 1, of the accompanying drawings, a steam separator 1 including a supplementary water supply pipe 10 provided with a water supply control valve 11, a steam separator pressure control valve 9 connected to a steam exhaust pipe 8, a steam separator pressure gauge 12 and a steam separator temperature indicator 13, a downcomer 2 connected to cooling tubes 7 in a stave 6 through a distribution manifold 5, and a riser 3 through which the cooling tubes 7 are connected to the steam separator 1 through a discharge manifold 4.

One of the problems which have been encountered in such natural circulation evaporative cooling apparatus is a water hammering phenomenon under low heat load conditions. In other words, while, during the early period after starting the operation of a blast furnace, the heat is effectively insulated by the bricks, etc., with the result that the heat load on the stave is low and hence the cooling water is maintained at a low temperature, generally after the lapse of about 6 months the heat load on the stave tends to increase gradually due to the wear or slagging of the bricks. With the cooling water maintained at a low temperature, the speed of the circulating water is very low, but the application of heat load in this state results in the production of steam bubbles or films within the cooling tubes. Such steam bubbles or films are intermittently cooled and condensed into water, and this intermittent phenomenon is called water hammering which causes considerable vibrations and noises. On the other hand, when the temperature of the cooling water is near the boiling point, the steam is not condensed by the cooling water, and the steam produced by the equilibrium conditions at the boiling temperature is easily converted into water thus causing no vibration phenomenon. Consequently, while the temperature of the cooling water rises generally giving rise to water hammering, this water hammering phenomenon ceases to occur as the cooling water temperature reaches near the boiling temperature. If such a water hammering phenomenon is allowed to occur continuously over a long period of time, the cooling tubes, the pipe flange joints and the welded joints will be damaged with the result that the cooling is no longer accomplished and the operation of the blast furnace is no longer carried out. Under these circumstances, there has existed a need for the development of an improved evaporative cooling apparatus which eliminates the occurrence of water hammering.

SUMMARY OF THE INVENTION

With a view to overcoming the foregoing difficulty, it is the object of the present invention to provide an improved evaporative cooling apparatus for a cooling stave which eliminates the foregoing difficulty with a simple arrangement comprising the introduction of high temperature steam into a steam separator of the conventional type.

As mentioned earlier, when the cooling water is at a low temperature, the application of heat load on the stave results in the production of steam bubbles or films within the cooling tubes, so that water hammering phenomenon is caused during the process of such bubbles or films being cooled and condensed into water. When the temperature of the cooling water is near the boiling point, vapor resulting from the equilibrium conditions at the boiling temperature is easily converted into water thus preventing water hammering. The present invention thus comprises an evaporative cooling apparatus in which cooling water at a temperature near the boiling point is circulated through the cooling tubes of a cooling stave to prevent water hammering. It comprises a steam separator 1 equipped with a heating steam inlet pipe 14 for maintaining the temperature of the cooling water at near the boiling point, a downcomer 2, a riser 3, a circulation activating pipe 16 interconnecting the downcomer 2 and the riser 3, a circulation activating steam feed pipe 17 for supplying steam into the circulation activating pipe 16 to circulate the cooling water through the downcomer 2, the circulation activating pipe 16, the riser 3 and the steam separator 1, a discharge manifold 4, a cooling stave 6 having cooling tubes 7 installed therein, and a distribution manifold 5, whereby when the supply of feed steam quantity is increased suitably, boiling phenomenon occurs in a part of the riser 3, the discharge manifold 4 and the circulation activating pipe 16, and the fraction dryness within the discharge manifold 4 and the riser 3 increases, causing circulation within the cooling tubes 7 of the stave 6 to circulate the cooling water at near the boiling temperature through the cooling tubes 7 from the steam separator 1 and thereby preventing the occurrence of water hammering phenomenon.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a flow diagram showing a conventional evaporative cooling apparatus for a cooling stave.

FIG. 2 is a flow diagram showing an embodiment of an evaporative cooling apparatus for a cooling stave according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will now be described in greater detail with reference to a preferred embodiment of the invention shown in FIG. 2. In the embodiment shown in FIG. 2, the evaporative cooling apparatus in accordance with this invention comprises a steam separator 1 including a supplementary water supply pipe 10 equipped with a water supply control valve 11, a steam separator pressure control valve 9 connected to a steam exhaust pipe 8, a steam separator pressure gauge 12 and a steam separator temperature indicator 13, a downcomer 2 leading from the steam separator 1 to cooling tubes 7 in a cooling stave 6 through a distribution manifold 5, and a riser 3 through which the cooling tubes 7 are connected to the steam separator 1 by way of a discharge manifold 4. An important feature of the present invention is its improved water hammer preventing arrangement. This arrangement includes a steam inlet pipe 14 connected to the steam separator 1 for heating the cooling water in the steam separator 1, a steam control valve 15 mounted in the path of the steam inlet pipe 14, a circulation activating pipe 16 for the cooling water connecting the paths of the downcomer 2 and the riser 3 together, a circulation activating steam feed pipe 17 connected to the circulation activating pipe 16, a steam control valve 20 mounted in the steam feed pipe 17, and control valves
3,892,392

18 and 19 arranged at the ends of the circulation activating pipe 16.

With the arrangement described above, the steam control valve 15 is controlled while watching the steam separator pressure gauge 12 and the steam separator temperature indicator 13, so that the steam is introduced into the steam separator 1 through the steam inlet pipe 14 and the water temperature is maintained at the boiling point corresponding to the internal pressure. On the other hand, steam is introduced into the circulation activating pipe 16 from the circulation activating steam pipe 17 to cause the circulation of the water through the downcomer 2, the circulation activating pipe 16, the riser 3 and the steam separator 1 and an increased quantity of the steam supplied causes boiling in a part of the discharge manifold 4 and the circulation activating pipe 16 with the result that the fraction dryness in the discharge manifold 4 and the riser 3 increases, and the circulation is also caused through the cooling tubes 7 in the stave 6 to circulate the cooling water at a temperature near the boiling point into the cooling tubes 7 from the distribution manifold 5. In this way, with practically no heat load on the stave, the cooling water at a temperature near the boiling point is circulated within the stave and therefore the occurrence of any water hammering phenomenon is prevented even during the eventual application of heat load on the stave.

Further, once a sufficiently large heat load has been applied on the cooling tubes 7 thus causing the required circulation through the cooling tubes 7, the same effect as described above is still maintained even after the circuits including the circulation activating pipe 16. Furthermore, instead of introducing steam into the steam separator 1 for heating the water in the manner described above, any other heating means may be used for heating purposes.

It sometimes happens that a localized increase in the heat load on the stave takes place for one cause or another while the blast furnace is in operation and steam bubbles are produced in the cooling tube located in the corresponding portion of the stave. In such case, the conventional evaporative cooling method is attended with a water hammering phenomenon. However, in the case of the present invention wherein the temperature of the cooling water is already near the boiling point at that time, there occurs no water hammering phenomenon for the above-stated reasons even in the presence of said locally increased heat load.

Again, when the temperature of the cooling water declines due to changes in the operating conditions of the blast furnace, as for example, when the supply of blast air is stopped temporarily so that the heat load on the stave is decreased, thus causing the cooling water temperature to decline gradually, the resumption of blast air feeding under such conditions inevitably causes a water hammering phenomenon in the case of the conventional evaporative cooling apparatus wherein cooling is effected by natural circulation. With the apparatus according to the present invention, however, by virtue of the fact that the hot water in the steam separator is always maintained at a temperature near the boiling point, the cooling water in the cooling tube of the stave is also maintained at a temperature near the boiling point, whereby no water hammering phenomenon is caused by an increase in the heat load due to resumption of blast air feeding.

It will thus be seen from the foregoing description that the present invention has a very high industrial utility value in that it is capable of eliminating water hammering phenomenon in the cooling stage thus ensuring safety of the cooling system and remarkably improved productivity of a blast furnace operation, and that it can be applied not only to the evaporative cooling of a blast furnace but also to the natural circulation boilers, etc.

What is claimed is:

1. An evaporative cooling apparatus for a cooling stave including a steam separator (1), a downcomer (2) coupled to said steam separator (1), a cooling stave (6) coupled to said downcomer and a riser (3) coupling said cooling stave (6) to said steam separator (1), the improvement comprising:

heating means (14, 15) for maintaining the temperature of water in said steam separator (1) at substantially the boiling point thereof,

circulation activating pipe means (16) in fluid communication with said cooling stave (6) for imparting a circulating force to cooling water in said cooling stave (6), and

steam feeding means (17) connected to feed steam to said circulation activating pipe means (16).

2. Apparatus according to claim 1 wherein said circulation activating pipe means (16) is coupled between said downcomer (2) and said riser (3).

3. Apparatus according to claim 2 wherein said steam feeding means (17) is connected to said circulation activating pipe means (16) between said downcomer (2) and riser (3).

4. Apparatus according to claim 3 wherein said circulation activating pipe means (16) includes a first valve means (18) located between said steam feeding means (17) and said riser (3), and a second valve means (19) located between said steam feeding means (17) and said downcomer (2).

5. Apparatus according to claim 4 wherein said steam feeding means (17) includes a steam control valve means (20).

6. Apparatus according to claim 1 wherein said heating means (14, 15) include steam supply means coupled to said steam separator (1) for heating the cooling water in said steam separator.

7. Apparatus according to claim 6 wherein said steam supply means includes a steam supply control valve (15) coupled in the path of the steam supply to said steam separator (1).