Title: METHOD OF HEATING LONG OBJECT IN RADIANT HEATING FURNACE AS WELL AS RADIANT HEATING FURNACE THEREFOR

Fig. 3

Abstract: An expected heat treatment is attained by imparting equal thermal history to a plurality of long objects charged into a box type radiant heating furnace. Specifically, when a plurality of long objects charged along lateral side walls constituting a long side of the box type heating furnace are heated at least by radiant heat from the lateral side walls, these long objects are arranged on a down-slope from the lateral side wall of the box type heating furnace toward a widthwise center of a hearth part thereof.
Description

Title of Invention: METHOD OF HEATING LONG OBJECT IN RADIANT HEATING FURNACE AS WELL AS RADIANT HEATING FURNACE THEREFOR

Technical Field

[0001] This invention relates to a method of heating a long object in a radiant heating furnace, wherein the long object in the furnace is particularly heated by radiant heat from a side wall of the furnace, as well as a radiant heating furnace therefor.

Background Art

[0002] In the production course of steel products, various heat treatments are performed for guaranteeing mechanical quality of the product or securing processability such as drawing process or the like (e.g. see Background art of Patent Document 1). In such heat treatments are used various types of heating furnaces depending upon purpose of the heat treatment, a shape and handling of a material to be heated, and so on. That is, long objects exemplifying steel pipe, steel bar and shaped steel are frequently treated in a batch-type heating furnace due to their size and shape.

[0003] For example, the steel pipe is subjected to a heat treatment under predetermined conditions for finally guaranteeing the mechanical quality of the product and thereafter stood to cool in air for shipping. To this heat treatment is applied a batch-type heating furnace.

Citation List

Patent Literature


Summary of Invention

Technical Problem

[0005] As the batch-type heating furnace is used a radiant heating furnace of box type having a laterally long length capable of sufficiently absorbing an axial length of an elongated steel pipe wherein a heater is disposed at an inside of a side wall constituting a lateral side face of the furnace and thermal energy is applied to the steel pipe through the side wall. When a plurality of long objects are disposed side by side in the widthwise direction of the furnace and subjected to the heat treatment, there is caused a problem that all long objects cannot be heated uniformly.

Therefore, the invention is to provide a method wherein plural long objects placed in the box type radiant heating furnace are subjected to equal thermal history to realize an expected heat treatment as well as a radiant heating furnace used therefor.
Solution to Problem

[0006] The inventors have found out that radiant heat from the lateral side wall in the box type radiant heating furnace is shut off by the steel pipes disposed in the furnace and does not arrive at a hearth part of the furnace as a main cause of the aforementioned non-uniform heating.

[0007] As shown in FIG. 1, a box type electric heating furnace as an example of the radiant heating furnace comprises four side walls 2a, 2b, 3a and 3b circumscribing a space on a hearth part 1 of the furnace, and a top seating 4 closing the circumscribed space. A heater 5 is disposed on each internal face of the lateral side walls 2a and 2b constituting long sides of the furnace so as to heat steel pipes 6 by radiant heat from the lateral side walls 2a and 2b in the furnace. In this box type electric heating furnace, the side walls 2a, 2b, 3a and 3b are integrally united with the top seating 4 to serve as a cover relative to the hearth part 1. That is, as shown in FIG. 1, a closed space can be formed on the hearth part 1 by disposing the steel pipes on the hearth part 1 and then placing the side walls 2a, 2b, 3a and 3b and the top seating 4 on the hearth part 1. Then, if the steel pipes 6 are heated by radiant heat from the lateral side walls 2a and 2b to complete given heating, the side walls 2a, 2b, 3a and 3b and the top seating 4 are lifted up from the hearth part 1 to expose the steel pipes 6 to atmosphere, whereby the steel pipes 6 are cooled in air.

[0008] Moreover, the heater 5 may be embedded in the top seating 4, but it is omitted because radiant heat from the lateral side walls 2a and 2b rises to sufficiently heat a portion just under the top seating 4. On the other hand, the heater is not arranged on the hearth part 1 because oxide scales are apt to be easily deposited on the hearth part 1 to cause violent damage on the heater existing on the hearth part 1.

[0009] Here, a plurality of steel pipes 6 are charged and heated in the furnace for ensuring the heat treating efficiency. As shown by a cross section of the furnace in FIG. 2, the charging form is that they are arranged side by side at approximately equal intervals on a pedestal 7 disposed on the hearth part 1. When the steel pipes 6 of such an arrangement are heated by radiant heat from the lateral side walls 2a and 2b, it has been confirmed that radiant heat is supplied to the steel pipes 6 from an outside of the arrangement in turn, but the heating rate becomes slow in the steel pipe located in a middle of the arrangement, particularly a portion thereof shadowed by the adjoining steel pipe 6, and further that portions of all steel pipes facing the hearth part 1 are not radiant region and can not expect radiant heat from the hearth part, and hence the heating rate becomes more slower.

[0010] As mentioned above, the heating of the steel pipe is performed for guaranteeing the mechanical quality or is a pretreatment prior to various works, so that it is required to
accomplish equal heating history and further cooling history over a full circumference of the steel pipe. However, when the plural steel pipes 6 are heated by arranging them as shown in FIG. 2, the thermal history as expected can not be applied to all of the steel pipes equally.

Now, the inventors have conceived that by reviewing the arrangement of the plural steel pipes charged in the radiant heating furnace to supply radiant heat from the lateral side walls 2a and 2b and further radiant heat from the hearth part 1 to all of the long objects can be imparted equal heating history to all of the steel pipes to realize the expected heat treatment, and as a result, the invention has been accomplished.

That is, the summary and construction of the invention are as follows.

(1) A method of heating a long object in a radiant heating furnace by charging a plurality of long objects along a lateral side wall constituting a long side of a laterally long box-type furnace and heating them by radiant heat at least from the lateral side wall, characterized in that the long objects are arranged on a down-slope from the lateral side wall of the box-type furnace toward a widthwise center of a hearth part thereof.

(2) The method of heating a long object in a radiant heating furnace according to the item (1), wherein the long objects are arranged so that an inclination angle q of a line segment connecting center cores of adjoining long objects to the face of the hearth part is not less than 10 degrees.

(3) The method of heating a long object in a radiant heating furnace according to the item (1) or (2), wherein the long objects are arranged so that a distance t between the adjacent long objects is not less than 0.05 times a diameter of the long object.

(4) A radiant heating furnace of a box type wherein a space on a hearth part is defined by a laterally long box and a heater is disposed on an inner face of a lateral side wall constituting a long side to heat a plurality of long objects charged in the furnace by radiant heat from the lateral side wall, characterized in that a plurality of pedestals mounting the long objects are arranged on a down-slope from the lateral side wall toward a widthwise center of the hearth part.

Moreover, a heat source of the radiant heating furnace used in the invention is an electrical resistance heating element (electric heater), a muffle or a radiant tube. The combustion is performed in refractory in case of the muffle and in tube in case of the radiant tube, respectively, or the heating element itself produces heat, and hence the material to be treated is heated by radiant heat generated from the refractory, tube or heating element. Also, a fan may be disposed in the furnace for making a temperature difference of atmosphere inside the furnace (e.g. difference of atmosphere temperature between upper part and lower part of the furnace).
Advantageous Effects of Invention

[0013] According to the invention, the expected heat treatment can be attained by imparting equal thermal history to plural long objects charged into the box type radiant heating furnace.

Brief Description of Drawings

[0014] [fig.1] FIG. 1 is a perspective view illustrating an outline of a box type radiant heating furnace;
[fig.2] FIG. 2 is a cross section illustrating the conventional arrangement of steel pipes in the box type radiant heating furnace;
[fig.3] FIG. 3 is a cross section illustrating an arrangement of steel pipes according to the invention in the box type radiant heating furnace;
[fig.4] FIG. 4 is a cross section illustrating an arrangement of steel pipes according to the invention in the box type radiant heating furnace;
[fig.5] FIG. 5 is a cross section illustrating an arrangement of steel pipes according to the invention in the box type radiant heating furnace;
[fig.6] FIG. 6 is a cross section illustrating an arrangement of steel pipes according to the invention in the box type radiant heating furnace;
[fig.7] FIG. 7 is a cross section illustrating an arrangement of steel pipes according to the invention in the box type radiant heating furnace;
[fig.8] FIG. 8 is a cross section illustrating an outline of the box type radiant heating furnace according to the invention; and
[fig.9] FIG. 9 is a cross section illustrating an outline of the box type radiant heating furnace according to the invention.

Best Mode for Carrying out the Invention

[0015] The method of heating long objects in the radiant heating furnace according to the invention will be described in detail by an example of using steel pipe as the long object with reference to the drawings below.

As shown in FIG. 3, the cross section of the furnace, similar to FIG. 2, it is essential that when a plurality of steel pipes 6 are charged and heated in the furnace, these steel pipes 6 are arranged on a down-slope from the lateral side wall 2a, 2b radiating heat toward a widthwise center O of the hearth part 1.

The arrangement with the down-slope from the lateral side wall 2a, 2b toward the widthwise center O of the hearth part 1 means that the height of the steel pipe from the hearth part 1 is gradually reduced from the steel pipe 6 located at the side of the lateral side wall 2a, 2b to the steel pipe 6 located at the widthwise center O, but also there may be at least a difference in height of the steel pipe from the hearth part 1 between the steel pipe 6 located closest to the lateral side wall 2a, 2b and the steel pipe 6
located near to the widthwise center O of the hearth part 1.

In other words, it is preferable to arrange the steel pipes so that radiant heat is directly applied to the steel pipes 6 located on the route from the lateral side wall 2a, 2b but also radiant heat to the hearth part 1 becomes large. More specifically, it is preferable that when the heights of the adjacent steel pipes are gradually shifted by increasing the height of the steel pipe 6 located closest to the lateral side wall 2a, 2b as far as possible to widen the space beneath the steel pipe 6, radiant heat is directly applied to each of the steel pipes but also radiant heat from the lateral side wall 2a, 2b to the hearth part 1 becomes larger.

FIG. 3 shows a case that the height of steel pipe is gradually reduced from the steel pipe 6 located near to the lateral side wall 2a, 2b to the steel pipe 6 located near to the widthwise center O.

On the other hand, the arrangement of steel pipes shown in FIG. 4 is mentioned as an example that the difference in height from the hearth part 1 is made at least between the steel pipe 6 located closest to the lateral side wall 2a, 2b and the steel pipe 6 located closest to the widthwise center O of the hearth part 1. Moreover, only the arrangement of the steel pipes is shown in FIG. 4, and the illustration of the pedestal is omitted. That is, the example of FIG. 4 is such an arrangement of steel pipes that there is substantially no difference in height between the steel pipe 6a located closer to the lateral side wall 2a, 2b and the steel pipe 6b adjacent to the steel pipe 6a and the difference in height is sufficient between the steel pipe 6a and the steel pipe 6c located near to the widthwise center O.

When the arrangement of steel pipes in the furnace is made to form the down-slope from the lateral side wall 2a, 2b toward the widthwise center O of the hearth part 1, thermal energy radiated from the lateral side walls 2a and 2b is applied to each of the steel pipes 6 located on the route and further applied to the hearth part 1. As a result, the hearth part 1 not subjected to radiant heat energy in the conventional technique is newly heated by the above thermal energy, and hence a portion of the steel pipe 6 facing to the hearth part 1, which was not subjected to the radiant heat in the conventional technique, is heated by radiant heat generated from the heated hearth part 1.

Furthermore, since the above arrangement of steel pipes forms the difference in height between the mutually adjacent steel pipes 6, the distance between the mutually adjacent steel pipes 6 can be set to wider as compared with the conventional case of horizontally arranging the steel pipes 6. That is, when the distance between the lateral side walls 2a and 2b is equal between the case of arranging steel pipes with the difference in height between the mutually adjacent steel pipes 6 and the case of horizontally arranging the steel pipes 6, the distance between the mutual steel pipes 6 can be widened in the arrangement with the difference in height. Also, radiant heat is
applied to the steel pipes 6 through such a distance, so that equal heating of the steel pipes can be attained more efficiently.

When the steel pipes are arranged on the down-slope, it is preferable that the height is gradually reduced from the steel pipe 6 located near to the lateral side wall 2a, 2b to the steel pipe 6 located at the widthwise center O as shown in FIG. 3. In this case, a gradient of the down-slope or an inclination angle q of a line segment connecting center cores of adjacent steel pipes 6 to the face of the hearth part 1 is preferable to be not less than 10 degrees.

Because, when the inclination angle is less than 10 degrees, the distance between the mutually adjacent steel pipes 6 can not be so widened as compared with the case of horizontally arranging the steel pipes, and the degree of arriving thermal energy radiated from the lateral side wall 2a, 2b at the hearth part 1 becomes smaller and the portion of the steel pipe 6 facing to the hearth part 1 is apt to be heated insufficiently.

For instance, the arrangement shown in FIG. 5 is a case that the inclination angle q is about 10 degrees in the adjacent steel pipes 6 without exception, and the arrangement shown in FIG. 6 is a case that the inclination angle K is about 25 degrees in the adjacent steel pipes 6 without exception.

In any case, it can be attained that radiant heat is applied to the hearth part 1 and also the distance between the mutually adjacent steel pipes 6 is made wider as compared with the conventional case of horizontally arranging the steel pipes.

Moreover, as the inclination angle K of the line segment connecting center cores of adjacent steel pipes 6 with respect to the face of the hearth part 1 becomes larger, each of the steel pipes can be heated more uniformly. However, when the inclination angle K exceeds 45 degrees, the quantity of radiant heat arriving at the each steel pipe is unchanged but also the top seating of the radiant heating furnace becomes higher, and hence it is difficult to perform handling operation of lifting up the side walls 2a, 2b, 3a and 3b and the top seating 4 from the hearth part 1 for conducting the cooling in air after the heating. Therefore, the upper limit of the inclination angle K is preferably not more than 45 degrees, more preferably not more than 30 degrees.

In the cases shown in FIGS. 3, 5 and 6, the inclination angle K between the adjacent steel pipes 6 is same in all of the steel pipes, but the inclination angle K between the adjacent steel pipes 6 may be different in lines, for example, as shown in FIG. 7. That is, there can be taken an arrangement of steel pipes that the inclination angle $K_1$ between the steel pipe 6a located closest to the lateral side wall 2a, 2b and the steel pipe 6b adjacent to the steel pipe 6a is 20 degrees and the inclination angle $K_2$ between the steel pipe 6b and the steel pipe 6c located near to the widthwise center O is 10 degrees. Even in the latter case, the arrangement of steel pipes with the down-slope is attained, so that radiant heat can be applied to the hearth part 1, and the distance
between the mutually adjacent steel pipes 6 can be widened as compared with the case of horizontally arranging the steel pipes. In this connection, the inclination angle $K$ between the adjacent lines is preferable to be not less than 10 degrees.

[0021] As shown in FIGS. 5 to 7, when the steel pipes are arranged on the down-slope, it is preferable that the distance $t$ between the mutually adjacent steel pipes 6 is not less than 0.05 times the diameter of the steel pipe. Because, in order to surely apply radiant heat to each of the steel pipes through such a distance, the distance $t$ is preferable to be at least not less than 0.05 times the diameter of the steel pipe. When the distance $t$ between the mutually adjacent steel pipes 6 is less than 0.05 times the diameter of the steel pipe, a shadowed portion is formed in the adjacent steel pipe relative to the radiant heat source and radiant heat is not applied to such a portion, and hence it is difficult to conduct the uniform heating of each of the steel pipes. More preferably, the distance $t$ between the mutually adjacent steel pipes is not less than 0.1 times the diameter of the steel pipe. As the distance $t$ between the mutually adjacent steel pipes becomes larger, each of the steel pipes can be heated more uniformly, but when the distance $t$ between the mutually adjacent steel pipes exceeds 1.0 times the diameter of the steel pipe, the quantity of radiant heat arriving at the each steel pipe is unchanged, so that the distance $t$ between the mutually adjacent steel pipes is preferably not more than 1.0 times the diameter of the steel pipe, more preferably not more than 0.5 times.

[0022] Next, the heating furnace directly used for the above heating method will be described with reference to FIGS. 8 and 9.

At first, the heating furnace of FIG. 8 shows that the pedestals 7 are arranged in correspondence to the arrangement of steel pipes 6 shown in FIG. 3, wherein these pedestals 7 are arranged to each other corresponding to the arrangement of steel pipes with the down-slope. Also, the heating furnace of FIG. 9 shows that the pedestals 7 are arranged in correspondence to the arrangement of steel pipes 6 shown in FIG. 4. As shown in the latter case, plural steel pipes 6 may be mounted on the one pedestal 7. Moreover, about 2 to 3 pedestals 7 may be arranged at equal intervals in axial direction every steel pipe 6.

[0023] In order to store thermal energy radiated from the lateral side walls 2a and 2b on the hearth part 1 efficiently, it is effective to pave heat storage materials having a small heat capacity, which are easily heated by radiant heat radiated from the lateral side walls 2a and 2b and can apply radiant heat from themselves, such as fiber wool or the like on the hearth part 1.

Moreover, it is more preferable that the heat storage material used in the floor member is attached to the top seating 4 because radiant heat from the top seating 4 can be also utilized.

**Example 1**
In a radiant heating furnace shown in FIG. 1, steel pipes are subjected to a heat treatment (tempering treatment: 780°C x 0.5h) under steel pipe arrangements of FIGS. 2, 5 and 6. As the steel pipe are used a steel pipe A having an outer diameter of 101.6 mm, a thickness of 7 mm and a length of 12.0 m and a steel pipe B having an outer diameter of 762 mm, a thickness of 15 mm and a length of 12.0 m, each of which has a composition comprising Cr: 9.0 mass%, Mo: 1.0 mass%, Nb: 0.08 mass% and V: 0.2 mass% and the remainder being Fe and inevitable impurities.

After the above heat treatment, temperatures are measured at 12 places on the periphery of each of the steel pipes to determine a difference between minimum temperature and maximum temperature. The measured results are shown in Table 1.

<table>
<thead>
<tr>
<th>Steel pipe arrangement</th>
<th>FIG. 2</th>
<th>FIG. 5</th>
<th>FIG. 6</th>
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<tr>
<td>Inclination angle K</td>
<td>0°</td>
<td>10°</td>
<td>25°</td>
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<tr>
<td>Steel pipe A</td>
<td>±13°C</td>
<td>±9°C</td>
<td>±9°C</td>
</tr>
<tr>
<td>Steel pipe B</td>
<td>±16°C</td>
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<tr>
<td>Remarks</td>
<td>Conventional Example</td>
<td>Invention Example</td>
<td>Invention Example</td>
</tr>
</tbody>
</table>

**Industrial Applicability**

According to the invention, it is possible to surely conduct the heat treatment of the long object including steel pipe, steel bar, shaped steel and the like.

**Reference Signs List**

1 hearth part
2a, 2b lateral side wall
3a, 3b side wall
4 top seating
5 heater
6 steel pipe
7 pedestal
Claims

[Claim 1] A method of heating a long object in a radiant heating furnace by charging a plurality of long objects along a lateral side wall constituting a long side of a laterally long box-type furnace and heating them by radiant heat at least from the lateral side wall, characterized in that the long objects are arranged on a down-slope from the lateral side wall of the box-type furnace toward a widthwise center of a hearth part thereof.

[Claim 2] The method of heating a long object in a radiant heating furnace according to claim 1, wherein the long objects are arranged so that an inclination angle $K$ of a line segment connecting center cores of adjoining long objects to the face of the hearth part is not less than 10 degrees.

[Claim 3] The method of heating a long object in a radiant heating furnace according to claim 1, wherein among the long objects, an inclination angle $K$ of a line segment connecting a center core of a long object at least closest to the lateral side wall to a center core of a long object adjacent to the said long object to the face of the hearth part is not less than 10 degrees.

[Claim 4] The method of heating a long object in a radiant heating furnace according to any one of claims 1 to 3, wherein the long objects are arranged so that a distance $t$ between the adjacent long objects is not less than 0.05 times a diameter of the long object.

[Claim 5] A radiant heating furnace of a box type wherein a space on a hearth part is defined by a laterally long box and a heater is disposed on an inner face of a lateral side wall constituting a long side to heat a plurality of long objects charged in the furnace by radiant heat from the lateral side wall, characterized in that a plurality of pedestals mounting the long objects are arranged on a down-slope from the lateral side wall toward a widthwise center of the hearth part.
[Fig. 8]

FIG. 8

[Fig. 9]

FIG. 9
### A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F27D5/00 (2006.01) i, C21D9/08 (2006.01) i

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)

Int.Cl. F27D5/00, C21D9/08

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

- Published examined utility model applications of Japan 1992-1996
- Published unexamined utility model applications of Japan 1971-2012
- Registered utility model specifications of Japan 1996-2012
- Published registered utility model applications of Japan 1994-2012

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

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category *</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>A</td>
<td>WO 2011/118201 A1 (SUMITOMO METAL INDUSTRIES, LTD.) 2011.09.29, Claims (No Family)</td>
<td>1-5</td>
</tr>
</tbody>
</table>

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
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"&" document member of the same patent family

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