The present invention provides a graphitized cathode block for aluminum smelting obtained by forming a raw material containing at least one calcined coke selected from the group consisting of calcined petroleum coke and calcined pitch coke, and a binder; baking the formed material to give a non-graphitized block; and graphitizing the non-graphitized block by resistive heating; wherein both end portions of the block have a higher electrical resistivity than the center portion thereof. By employing the cathode block of the present invention, during electrolytically smelting aluminum, current may be uniformly flowed as the concentration of current at both end portions of the cathode block is lightened, and it becomes possible to maximize the advantages of graphitized cathode blocks.
**FIG. 2**

**FIG. 3**
GRAPHITIZED CATHODE BLOCK FOR ALUMINUM SMELTING

BACKGROUND OF THE INVENTION

0001) 1. Field of the Invention

0002) The present invention relates to a graphitized cathode block to be used in an electrolytic pot for aluminum smelting and the manufacturing method thereof.

0003) 2. Description of the Related Art

0004) Two types of representative cathode blocks are known for use in an electrolytic pot for aluminum smelting: namely, a baked cathode block obtained by molding a kneaded mixture, which is prepared by adding a binder such as a coal tar pitch to calcined anthracite or calcined anthracite containing graphite, into a prescribed shape, and baking the molded mixture at about 1000°C; and a graphitized cathode block obtained by molding a kneaded mixture of a binder such as coal tar pitch and calcined petroleum coke or calcined pitch coke into a prescribed shape, baking the molded mixture at about 1000°C to give a non-graphitized block, and thereafter graphitizing it at a temperature of 2000°C or higher.

0005) Among the above, in comparison to the baked cathode block, swelling against the electrolytic bath is extremely small with the graphitized cathode block and the life span of the electrolytic pot can be extended. Moreover, another characteristic of the graphitized cathode block is that as the voltage drop in the cathode is low due to electrical resistivity being low, large current operation is possible and productivity becomes superior. Therefore, in recent years, the use of graphitized cathode blocks as the cathode block to be used in an electrolytic pot for aluminum smelting is increasing considerably.

0006) FIG. 3 is a diagram typically showing the current distribution state in an aluminum electrolytic pot.

0007) The arrows in FIG. 3 show the distribution state of the current flowing in the cathode block arranged in the aluminum electrolytic pot when conducting electrolytic smelting of aluminum with a graphitized cathode block.

0008) As clear from FIG. 3, the current flowing substantially vertically from the anode 9 passes through the graphitized cathode block 10 and then flows to a collector bar 11 made from iron. Nevertheless, as the current exit is positioned at both ends of the cathode block 10, the current inside the graphitized cathode block is divided more in the horizontal direction, and there is a tendency for the current to be concentrated at both end portions of the block, specifically, the portions up to 25% of the entire block length from the both block ends. This tendency is particularly evident in a cathode block with a lower electrical resistivity.

0009) In case of conducting a large current operation in the electrolytic smelting of aluminum, the aforementioned concentration of current at both end portions of the block becomes prominent, and major problems tend to arise; for example, the decrease in the current efficiency due to the unstableness of the pot resulting from local changes of aluminum fluidity, and the decrease in life span of the pot due to the accelerated abrasion of the graphitized cathode block.

0010) As mentioned above, at present, a graphitized cathode block for aluminum smelting is manufactured, in principle, by a method of using calcined coke and pitch as the raw material, molding and baking the raw material to obtain a non-graphitized block, and thereafter graphitizing the non-graphitized block by resistive heating. There are two representative examples known for the graphitizing method in the aforementioned process; namely, the indirect energizing method (i.e., the method using so-called Acheson furnace) and the direct energizing method (i.e., the method using so-called LWG furnace). Among the methods described above, in comparison to the indirect energizing method, the direct energizing method is superior with respect to uniformity of the product’s quality, number of days required for the treatment process, energy efficiency, working environment and so on. Nevertheless, in the direct energizing method, the temperature easily rises at the contact portion of two block ends due to the heat generation at the contact portion being larger in some measure, and there is a tendency for the electrical resistivity of both end portions of the block to be the same as or lower than the center portion thereof. As a result, in case of using the cathode block manufactured by the direct energizing method, current is easily concentrated at both end portions of the block when conducting electrolytic smelting of aluminum, and there are drawbacks such as the decrease in current efficiency and in the life span of the pot as described above.

SUMMARY OF THE INVENTION

0011) A principle object of the present invention is to provide a graphitized cathode block for aluminum smelting, and the manufacturing method thereof, the graphitized cathode block being capable of maximizing the advantages of the graphitized cathode block by reducing the concentration of current at both end portions of the cathode block and uniformly flowing current during electrolytically smelting aluminum.

0012) Inventors of the present invention have conducted intense research in consideration of the aforementioned problems. As a result, they have discovered that in the method of serially aligning the non-graphitized block in a graphitization furnace and graphitizing the block by the direct energizing method, when a current distributor for dividing the flow of current is arranged at the periphery of the contact portion of the non-graphitized blocks, it is possible to preferentially flow the current to the adjacent block via the current distributor, and the electrical resistivities of the block end portions after graphitization become higher in comparison to the center portion because the quantity of electricity through the contact portion at block end is less than that at the block center. Moreover, the present inventors have discovered that by using the graphitized block obtained as described above as the cathode block for aluminum smelting, it is possible to decrease the concentration of the current at the block end portions when conducting electrolytically smelting of aluminum. Based on these findings, the present invention was completed.

0013) In other words, the present invention provides a graphitized cathode block for aluminum smelting and the manufacturing method thereof as described below.

0014) 1. A graphitized cathode block for aluminum smelting obtained by forming a raw material con-
containing at least one calcined coke selected from the group consisting of calcined petroleum coke and calcined pitch coke, and a binder; baking the formed material to give a non-graphitized block; and graphitizing the non-graphitized block by resistive heating; wherein both end portions of the block have a higher electrical resistivity than the center portion thereof.

[0015] 2. A graphitized cathode block for aluminum smelting according to paragraph 1 above, wherein the electrical resistivity of the center of the block is within a range of 8 to 17 μΩm, and the electrical resistivities of the portions up to at least 15% of the entire block length from both ends of the block are respectively higher than that of the center by 0.5 to 3 μΩm and within a range of 8.5 to 20 μΩm.

[0016] 3. A method of manufacturing the graphitized cathode block according to paragraph 1 or paragraph 2 above, comprising the steps of:

[0017] forming a raw material containing at least one calcined coke selected from the group consisting of calcined petroleum coke and calcined pitch coke, and a binder;

[0018] baking the formed material to give a non-graphitized block;

[0019] serially connecting two or more of the non-graphitized blocks and arranging a current distributor(s) at the periphery of the contact portion(s) of the blocks; and

[0020] applying an electric current to the non-graphitized block to produce a graphitized block.

[0021] 4. A method of manufacturing the graphitized cathode block according to paragraph 3 above, wherein the current distributor is composed of graphite plates fixed at the periphery of the contact portion of the blocks.

[0022] 5. A method of manufacturing the graphitized cathode block according to paragraph 4 above, wherein the current distributor is composed of graphite plates each having a thickness of 5 to 15 cm, a length capable of covering a portion up to at least 15% of the entire block length from the block end, and a width that is 90 to 98% of the width of the non-graphitized block.

[0023] In order to manufacture the graphitized cathode block for aluminum smelting according to the present invention, a non-graphitized block is manufactured in a prescribed shape prior to graphitization.

[0024] Used to manufacture the non-graphitized block is raw material containing at least one calcined coke selected from the group consisting of calcined petroleum coke and calcined pitch coke, and a binder. Coal tar pitch, thermoplastic resin, and so on may be used as the binder.

[0025] The usage ratio of calcined coke and the binder may be about 20 to about 30 parts by weight of the binder to 100 parts by weight of the calcined coke.

[0026] In order to manufacture the non-graphitized block, at first, raw material containing these substances is formed into a prescribed shape. There is no particular limitation to the forming method and employed may be, for example, extrusion molding, mold forming, vibration molding and other forming methods. The specific shape of the formed product may be appropriately decided in consideration of the shrinkage, etc., during the graphitization process and in accordance with the shape of the electrolytic pot for aluminum smelting to be used.

[0027] Next, the formed product is baked to produce a non-graphitized block. Here, the baking temperature may be about 800 to about 1200°C, and the baking atmosphere may be a reduction atmosphere.

[0028] After obtaining the non-graphitized block, the non-graphitized block can be graphitized by serially connecting two or more non-graphitized blocks and sending an electric current to the blocks by the direct energizing method.

[0029] Here, prior to sending an electric current, a current distributor for dividing the flow of the current is arranged at the periphery of the contact portion of the non-graphitized blocks. As a result of arranging a current distributor at the contact portion of the non-graphitized blocks, current preferentially flows to the adjacent block via the current distributor. Thus, the electric current and the amount of heat generation decrease at both end portions of the blocks at which the blocks are connected and the current distributor is arranged, and the electrical resistivities of the block end portions after graphitization become higher in comparison to the block center portion.

[0030] As the schematic diagram of the graphitization device for a direct energizing method (so-called LWG furnace) in which a non-graphitized blocks are graphitized, Fig. 1 shows a cross section of the graphitization device in which a portion of the thermal insulation packing is cut away. This device comprises a furnace body 1, transformer 2, pusher 3, terminal 4, non-graphitized block 5, thermal insulation packing 6, current distributor 7, and clamping jig 8.

[0031] In Fig. 1, after aligning a plurality of non-graphitized blocks 5, the current distributor 7 is uniformly applied to four surfaces, namely, the top surface, the bottom surface and both side surfaces at the contact portion of the adjacent blocks and secured with the clamping jig. Furthermore, the non-graphitized blocks aligned in a single row are covered with thermal insulation packing 6 for thermal insulation and prevention of oxidation and then an electric current is applied. Moreover, in the device shown in Fig. 1, a current distributor 7 is also arranged at the contact portion of the terminal 4 and the non-graphitized block 5.

[0032] As the current distributor 7, any material having a lower electrical resistivity than the contact portion of the non-graphitized blocks can be used; however, it is more preferable to use a graphite plate(s). Fig. 2 is a perspective diagram of the contact portion of the non-graphitized blocks in the case of using graphite plates as the current distributor. In Fig. 2, the graphite plates used as the current distributor 7 are uniformly applied to four surfaces; namely, the top surface, the bottom surface and the both side surfaces at the contact portion of the non-graphitized blocks 5 and secured with the clamping jig 8.

[0033] When using the graphite plates as the current distributor, the thickness of the graphite plate is preferably in the range of about 5 to about 15 cm. If the graphite plate
is too thin, it is difficult to make the current flow to the current distributor, and the electrical resistivities of both end portions of the block remain low in comparison to the center portion and hardly any effect is obtained. Meanwhile, if the graphite plate is too thick, the electrical resistivities of the block end portions becomes too high, the swelling against the electrolytic bath becomes large, and the life span of the electrolytic pot itself is shortened, which is undesirable.

[0034] Preferably, the width of the current distributor is the same as the width of the non-graphitized block. Nevertheless, in consideration of the shrinkage of the non-graphitized block, the width of the current distributor will suffice if it is 90 to 98% of the width of the non-graphitized block.

[0035] The length of the current distributor will suffice if it is of a length capable of sufficiently covering the end portion of the block to which current is easily concentrated. Ordinarily, it is preferable if the length of the current distributor is capable of covering up to at least 15% of the portion of the entire block length from the block end. Moreover, as the up to 25% of the portion of the block length from the block end is most easily eroded, it is further preferable that the length of the current distributor is capable of covering such portion.

[0036] Although the condition of applying an electric current may be decided in accordance with the specific shape of the block or number of blocks and so on, it is necessary to apply an electric power in a range in which both end portions of the block having the minimal heat generation amount will be sufficiently graphitized. Ordinarily, the electric power may be selected such that both end portions of the block are heated to about 2000° C. or higher by resistive heating.

[0037] According to the method of the present invention, by utilizing the current distributor, the heat generation amount of both end portions of the block becomes less than that of the block center portion, and it is thereby possible to obtain a graphitized block wherein both end portions of the block have an electrical resistivity higher than the center portion.

[0038] With the obtained graphitized block, preferably, the electrical resistivity of the block center is within a range of about 8 to about 17 μΩm, the electrical resistivities of the portions up to at least 15% of the entire block length from both ends thereof, respectively, are 0.5 to 3 μΩm higher than that of the block center and within a range of 8.5 to 20 μΩm. More preferably, the electrical resistivities of the portions up to 25% of the entire block length from both ends thereof, respectively, which are the portions that are most easily eroded, are 0.5 to 3 μΩm higher than that of the block center and within a range of 8.5 to 20 μΩm.

[0039] By appropriately setting the thickness and size of the current distributor in accordance with the energization condition, it is possible to manufacture a block having the aforementioned electrical resistivities.

[0040] And by using a graphitized block having such electrical resistivity as the cathode block, the concentration of current at the block end portions during electrolytic smelting of aluminum is lightened, and it is possible to improve the current efficiency and pot life. Contrarily, if the electrical resistivity is too low, the graphitized cathode block itself becomes too soft and this is undesirable as the abrasion resistance will decrease. Meanwhile, if the electrical resistivity is too high, the swelling against the electrolytic bath becomes large, and this is undesirable as the life span of the electrolytic pot will be shortened.

[0041] When using the graphitized cathode block according to the present invention as the cathode block for electrolytic smelting of aluminum, the concentration of current at both end portions of the block is lightened, and it is possible to improve the uniformity of the current distribution in the cathode block. As a result, by conducting electrolytic smelting of aluminum with the present graphitized cathode block, the current efficiency during electrolytic smelting is improved and the life span of the electrolytic pot is considerably extended.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] FIG. 1 is a cross section of the graphitization device for the direct energizing method in which a portion of the thermal insulation packing is cut away;

[0043] FIG. 2 is a perspective diagram of the contact portion of the non-graphitized blocks; and

[0044] FIG. 3 is a diagram typically showing the current distribution state in an aluminum electrolytic pot.

[0045] The reference numerals indicated in the drawings represent a furnace 1, transformer 2, pusher 3, terminal 4, non-graphitized block 5, thermal insulation packing 6, current distributor 7, clamping jig 8, anode 9, graphitized cathode block 10 and collector bar 11.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0046] The present invention is now described in further detail with reference to the following examples.

EXAMPLE 1

[0047] Coal tar pitch (softening point 95° C.), 30 parts by weight was mixed with 100 parts by weight of calcined petroleum coke, kneaded at 150° C. for 60 minutes with a two-arm type kneader, cooled to 110° C., placed in a container, and molded into a size of width 700 mm×thickness 300 mm×length 3500 mm with a transverse extrusion press.

[0048] Next, with a Ried-hammer type continuous furnace, a non-graphitized block was obtained by baking the obtained mold block in a reduction atmosphere in the condition of raising the temperature up to a maximum temperature of 1000° C. for about 20 days.

[0049] Then, five non-graphitized blocks were serially aligned inside the direct energizing graphitization furnace, the contact portions of the adjacent blocks were secured by being uniformly covered with two graphite plates having a thickness of 5 cm, length of 70 cm and width of 60 cm and two graphite plates having a thickness of 5 cm, length of 70 cm and width of 47 cm, an electric current was applied to the blocks to graphitize the blocks at a temperature higher than 2000° C.

[0050] The measurement results of the electrical resistivities of the center and end portion of the obtained graphitized block are shown in Table 1 below. Moreover, the life span
of the electrolytic pot when using the obtained graphitized block in the electrolytic pot for aluminum smelting is also shown in Table 1 below.

EXAMPLES 2 to 6

[0051] A graphitized block was manufactured in a similar manner as with Example 1, other than that the thickness and length of the current distributor were as per Table 1 below.

[0052] The electrical resistivities and the life span of the electrolytic pot when using the obtained graphitized block in the electrolytic pot for aluminum smelting are shown in Table 1 below.

EXAMPLES 7 to 12

[0053] Graphitized cathode blocks were manufactured in a similar manner as with Examples 1 to 6, respectively, other than that calcined pitch coke was used instead of calcined petroleum coke.

[0054] The electrical resistivities and the life span of the electrolytic pot when using these obtained graphitized blocks in the electrolytic pot for aluminum smelting were both the same as with the case of using calcined petroleum coke as the raw material.

COMPARATIVE EXAMPLE 1

[0055] A graphitized block was manufactured in a similar manner as with Example 1, other than that a current distributor was not used.

[0056] The electrical resistivities and the life span of the electrolytic pot when using the obtained graphitized block in the electrolytic pot for aluminum smelting are shown in Table 1 below.

COMPARATIVE EXAMPLE 2

[0057] The electrical resistivities and the life span of the electrolytic pot when using the baked block, which was obtained by molding the kneaded mixture of calcined anthracite containing graphite and pitch binder into a prescribed shape and baked at 1000° C., in the electrolytic pot for aluminum smelting are shown in Table 1 below.

<table>
<thead>
<tr>
<th>Thickness of Current Distributor(cm)</th>
<th>Life Span of Electrolytic Pot (number of days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1898</td>
</tr>
<tr>
<td>5</td>
<td>1905</td>
</tr>
<tr>
<td>10</td>
<td>1971</td>
</tr>
<tr>
<td>10</td>
<td>2008</td>
</tr>
<tr>
<td>15</td>
<td>2059</td>
</tr>
<tr>
<td>15</td>
<td>2081</td>
</tr>
<tr>
<td></td>
<td>1643</td>
</tr>
<tr>
<td></td>
<td>1387</td>
</tr>
</tbody>
</table>

TABLE 1-continued

<table>
<thead>
<tr>
<th>Life Span of Electrolytic Pot (number of days)</th>
<th>Examples</th>
<th>Comparative Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1898</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1905</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>1971</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2008</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2059</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2081</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>1643</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1387</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[0058] As a result of the above, it is clear that according to the present invention, a graphitized block having a higher electrical resistivities at the end portions of the block than the center portion thereof can be obtained and the life span of the electrolytic pot for aluminum smelting has been extended considerably.

What is claimed is:

1. A graphitized cathode block for aluminum smelting obtained by forming a raw material containing at least one calcined coke selected from the group consisting of calcined petroleum coke and calcined pitch coke, and a binder; baking the material to give a non-graphitized block; and graphitizing said non-graphitized block by resistive heating; wherein both end portions of the block have a higher electrical resistivity than the center thereof.

2. A graphitized cathode block for aluminum smelting according to claim 1, wherein the electrical resistivity of the block center is within a range of 8 to 17 μΩm, and the electrical resistivities of the portions up to at least 15% of the entire block length from both ends of the block are respectively higher than that of the block center by 0.5 to 3 μΩm and within a range of 8.5 to 20 μΩm.

3. A method of manufacturing the graphitized cathode block according to claim 1 or claim 2, comprising the steps of:

a. forming a raw material containing at least one calcined coke selected from the group consisting of calcined petroleum coke and calcined pitch coke, and a binder;
b. baking the formed material to give a non-graphitized block;
c. serially connecting two or more of said non-graphitized blocks and arranging a current distributor(s) at the periphery of the contact portion(s) of the blocks; and applying an electric current to the non-graphitized blocks to produce a graphitized block.

4. A method of manufacturing the graphitized cathode block according to claim 3, wherein said current distributor is composed of graphite plates fixed at the periphery of the contact portion of the blocks.

5. A method of manufacturing the graphitized cathode block according to claim 4, wherein said current distributor is composed of graphite plates each having a thickness of 5 to 15 cm, a length capable of covering a portion up to at least 15% of the entire block length from the block end, and a width that is 90 to 98% of the width of the non-graphitized block.

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