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(57) Abrégé/Abstract:
Process for continuous graphitization, carried out in a tunnel furnace having a transport device, heat locks at the inlet and outlet of the furnace and in the interior of the furnace at least one heating section whose length is less than the length of the bodies to be graphitized and whose heating power is altered according to the movement of the bodies, in particular for cathode blocks which are used in the electrolytic reduction of aluminum oxide.

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Abstract

Process for continuous graphitization

Process for continuous graphitization, carried out in a tunnel furnace having a transport device, heat locks at the inlet and outlet of the furnace and in the interior of the furnace at least one heating section whose length is less than the length of the bodies to be graphitized and whose heating power is altered according to the movement of the bodies, in particular for cathode blocks which are used in the electrolytic reduction of aluminum oxide.

Process for continuous graphitization

The invention relates to a process for continuous graphitization, in particular of cathode blocks for the electrolytic production of aluminum.

In the electrolytic production of aluminum by the Hall-Héroult process, use is made of electrolysis cells which have a bottom which is made up of a plurality of blocks and acts as cathode. The electrolyte is a melt, effectively a solution of aluminum oxide in cryolite. The working temperature is, for example, about 1 000°C. The electrolytically generated molten aluminum collects on the bottom of the cell under a layer of the electrolyte. The cells are surrounded by a metallic housing (preferably steel) lined with high-temperature-resistant material.

Owing to the chemical resistance and thermal stability required, the material of the cathode blocks is preferably carbon which may have been partially or completely graphitized by means of thermal treatment. Such cathode blocks are produced by mixing pitches, cokes, anthracite and/or graphite in selected particle sizes or particle size distributions for the solids and shaping, firing and, if appropriate, (partially) graphitizing the mixtures. Firing (carbonization) is usually carried out at temperatures of about 1 200°C, and the graphitization is usually carried out at temperatures above 2 400°C.

While graphitized cathodes are preferred because of their higher electrical conductivity, they display increased corrosion during operation, corresponding to a mean annual decrease in their thickness of up to 80 mm. This corrosion is not distributed uniformly over the length of the cathode blocks (corresponding to the width of the cell), but the surface of the cathode blocks is changed to a W-shaped profile. Due to the nonuniform removal of material, the useful life of the cathode blocks is limited by the areas having the greatest removal of material.

One possible way of making the removal of material more uniform over the length of the cathode block and thus increasing the useful life is to configure the cathode blocks so that their electrical resistance varies over the length in such a way that the current density (and thus the corrosion) is uniform over their length or at least displays a very small deviation from its mean over the length.

One solution is described in DE 20 61 263, in which composite cathodes are made up of either a plurality of carbon blocks which have different electrical conductivities and are arranged so that a uniform or approximately uniform current distribution results, or of carbon blocks whose electrical resistances increase continuously in the direction of the cathodic terminals. The number of carbon blocks and their electrical resistance depends in each case on the size and type of the cell and have to be calculated afresh for each case. Cathode blocks made up of a plurality of individual carbon blocks are complicated to construct; the joins also have to be sealed well in order to prevent the liquid aluminum flowing out at the joins.

WO 00/46426 describes a graphite cathode consisting of a single block which has an electrical conductivity which can be changed over its length, with the conductivity being lower at the ends of the block than in the middle. This nonuniform distribution of electrical conductivity is achieved by bringing the end zones to a temperature of from 2 200 to 2 500°C during the graphitization, while the middle zone is exposed to a temperature of from 2 700 to 3 000°C. This different heat treatment can be achieved in two ways according to these teachings: on the one hand, the loss of heat by conduction in the graphitization furnace can be limited differently, or heat sinks can be provided in the vicinity of the end zones so as to increase the heat loss. In the case of a transverse graphitization, the density of the thermally insulating bed is altered so that the heat loss over the length of the cathodes becomes nonuniform and the desired temperatures are obtained as a result. In the case of longitudinal graphitization, too, the heat loss in the vicinity of the ends can be increased by different configuration of the thermally insulating bed, or bodies which conduct heat away, preferably graphite bodies, are installed for this purpose in their vicinity so as to produce greater outward heat flow to the furnace wall.

According to another method, the difference in the heat treatment can be achieved by local changes in the current density, with the result of different heat evolution. This change in the current density can, according to the teachings, be achieved by different resistances of the conductive bed between two cathodes in an Acheson furnace (transverse graphitization); no such solution is indicated for a longitudinal graphitization process.

These known methods have considerable disadvantages for industrial use. A difference of 500°C between the desired graphitization temperatures in the middle and at the ends of the cathodes cannot be achieved by means of heat sinks alone. The required difference between heat conduction to the outside results in a considerable energy loss which significantly increases the costs of manufacture. The higher heat loss toward the side of the furnace also means a higher thermal stress which makes the construction of the furnace more expensive or reduces its life. Finally, an inhomogeneity in the thermally insulating bed or the conductive bed is not very practical, since the bed material would have to be introduced in a plurality of steps and have to be classified again according to its thermal conduction or electrical conductivity after the furnace cycle is concluded and the cathodes are removed.

It is therefore an object of some embodiments of the present invention to provide a practical process for producing cathodes which have a differing electrical conductivity over their length.

According to the present invention, there is provided a process for continuous graphitization, carried out in a tunnel furnace having a transport device, heat locks at the inlet and outlet of the furnace and in the interior of the furnace at least one heating section whose length is less than the length of the bodies to be graphitized and whose heating power is altered according to the movement of the bodies.

Some embodiments provide a continuous graphitization process starting from, in particular, carbonized electrode blocks, carried out in a tunnel furnace having a transport device, heat locks at the inlet and outlet of the furnace and in the interior of the furnace at least one heating section whose length is less than the length of the electrode blocks and whose heating power is altered according to the movement of the electrode blocks.

Basic heating of the bodies to be graphitized is preferably ensured by means of conductive heating. Electric power can be supplied to the individual blocks, and the power leads are then advantageously not attached directly to the ends of the blocks but the power is supplied, for example, via sleeves in the outer zones.

The distance from the ends of the bodies can be up to 10% of their length. However, it is also possible for the electric power to be supplied via the ends or the end faces of the bodies. The energy introduced by means of conductive heating is advantageously such that on its own it heats the bodies to temperatures of not more than 2 650°C, preferably up to 2 500°C and in particular up to 2 200°C.

For the purposes of the invention, it is also possible for the electric power for conductive heating to be supplied in such a way that more than one body is conductively heated by means of this current. This embodiment corresponds in principle to those in which the electric power is supplied to an individual body via its end faces. Of course, the conditions for the energy supplied as set forth in the previous paragraph also apply.

The additional energy necessary to reach the temperatures required for the graphitization can be supplied by inductive heating or by means of radiative heating. The heating elements for this purpose preferably have a length which is less than that of the bodies to be graphitized. For the purposes of the present invention, the length of a heating element is the distance in the direction of the length of the bodies to be graphitized which is operated at essentially constant energy output over this length; in particular, it is not the physical length of the heating element. For example, the additional heating can be provided using arrangements of inductive heating elements in which the effective length of the individual elements is not more than 50% of the length of the bodies to be graphitized. The effective length is preferably up to 30% of the length of the bodies, in particular up to 20%. In place of the inductive heating elements or in combination therewith, it is also possible to use radiative heating elements for whose geometries the same conditions as for the inductive heating elements apply.

The time for which the additional heating element(s) is/are switched on and the points in time at which switching on and off occur are, according to the invention, selected so that the middle zones (based on the longitudinal direction of the bodies) are subjected to a higher energy input and therefore are brought to higher temperatures, preferably to temperatures of at least 2 650°C, preferably at least 2 700°C, in particular to temperatures in a range from 2 700 to 3 000°C. According to the invention, it is also possible for the additional heating elements not to be switched off completely when the end zones or the zones close to the end reach the effective region of the additional heating elements, but for them to be operated merely at a reduced energy output. In this case, the energy output should be reduced by at least 10% when the end zones reach the effective region of the additional heating elements.

If the furnace has a plurality of heating sections, preference is given to altering their power as a function of time so that the heating section which is in each case in the middle of a body to be graphitized is operated at its nominal power while the heating sections in which one end or a segment close to the end of one of the bodies to be graphitized are located are operated at an at least 5% lower power.

Claims

1. A process for continuous graphitization, carried out in a tunnel furnace having a transport device, heat locks at the inlet and outlet of the furnace and in the interior of the furnace at least one heating section whose length is less than the length of the bodies to be graphitized and whose heating power is altered according to the movement of the bodies.

2. The process as claimed in claim 1, wherein the heating section comprises a conductive heating facility in which the distance between the power leads is less than the length of one of the bodies to be graphitized.

3. The process as claimed in claim 1, wherein the heating section comprises an inductive heating facility.

4. The process as claimed in claim 1, wherein the heating section comprises a combination of at least two types of heating selected from among radiative heating, conductive heating and inductive heating.

5. The process as claimed in claim 1, wherein the power of the heating section is reduced by at least 10% when the ends of one of the bodies to be graphitized pass through the heating section.

6. The process as claimed in any one of claims 1 to 5, wherein the furnace comprises a plurality of heating sections whose power is altered

as a function of time so that at least the heating section in which the middle of one of the bodies to be graphitized is located is operated at its nominal power while the heating sections in which one end or a segment close to the end of one of the bodies to be graphitized are located are operated at an at least 5% lower power.

7. The process as claimed in any one of claims 1 to 6, wherein the bodies to be graphitized are carbonized cathode blocks for the electrolytic reduction of aluminum oxide.