

(19) AUSTRALIAN PATENT OFFICE

(54) Title

A method and a prebaked anode for aluminium production

(51)⁶ International Patent Classification(s)

C25C 7/00 (2006.01) 3/08

C25C 3/08 (2006.01) 20060101ALI2006122

C25C 3/12 (2006.01) 8BHSE **C25C**

C25C 7/00 3/12

20060101AFI2006122 20060101ALI2006122

8BHSE **C25C** 8BHSE

PCT/NO2006/000221

(21) Application No: 2006259914

(22) Application Date: 2006 .06 .09

(87) WIPO No: W006/137739

(30) Priority Data

(31) Number	(32) Date	(33) Country
20053072	2005 .06 .22	NO

(43) Publication Date : 2006 .12 .28

(71) Applicant(s)

Norsk Hydro ASA

(72) Inventor(s)

Storesund, Arild

(74) Agent/Attorney

Phillips Ormonde Fitzpatrick, 367 Collins Street, Melbourne, VIC, 3000

(56) Related Art

US 2958641 A

US 3438876 A

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
28 December 2006 (28.12.2006)

PCT

(10) International Publication Number
WO 2006/137739 A1

(51) International Patent Classification:
C25C 7/00 (2006.01) C25C 3/12 (2006.01)
C25C 3/08 (2006.01)

(21) International Application Number:
PCT/NO2006/000221

(22) International Filing Date: 9 June 2006 (09.06.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
20053072 22 June 2005 (22.06.2005) NO

(71) Applicant (for all designated States except US): **NORSK
HYDRO ASA** [NO/NO]; N-0240 Oslo (NO).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **STORESUND, Arild**
[NO/NO]; Tidsbakkane 111, N-4250 Kopervik (NO).

(74) Agent: **BERG, André**; Patent and Trademark Department,
Hydro Aluminium AS, N-0240 Oslo (NO).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,
KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV,
LY, MA, MD, MG, MK, MN, MW, MX, MY, NA, NG, NI,
NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE,
SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG,
US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HU, IE, IT, LI, LU, LV, MC, NL, PL, PT,
RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA,
GN, GQ, GW, ML, MR, NE, SN, TD, TG).

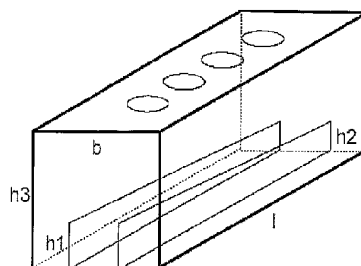
Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: A METHOD AND A PREBAKED ANODE FOR ALUMINIUM PRODUCTION

h1 = 350 mm
h2 = 320 mm
slot width = 3-8 mm
l = 1510 mm
h3 = 600 mm
b = 700 mm



(57) Abstract: Present invention relates to a method of producing aluminium in an Hall-Héroult cell with prebaked anodes, as well as anodes for same. The anodes are provided with slots in its wear (bottom) surface for gas drainage. The slots are 2-8 millimetres wide, preferably 3 millimetres.

WO 2006/137739 A1

03 Aug 2010

2006259914

A Method and a Prebaked Anode for Aluminium Production

The present invention relates to an optimised method for performing an electrolysis process for producing aluminium in accordance with the Hall-Héroult process with prebaked anodes, and anodes therefore.

A reference herein to a patent document or other matter which is given as prior art is not to be taken as an admission that that document or matter was, in Australia, known or that the information it contains was part of the common general knowledge as at the priority date of any of the claims.

In a process as described above, there will be evolved gas at the wear-surface (primary the underside or bottom side) of anodes due to the reduction of alumina. In particular carbon dioxide gas will accumulate at this surface, causing variations and instabilities in the electrical contact from the anode to the electrolyte. This physical phenomena have several drawbacks, such as:

- Increased back reaction and loss of current efficiency due to close contact between the produced aluminium layer and CO₂ gas bubbles.
- Increased possibility and duration of anode effects.
- Heat production in the gas layer results in a reduced interpolar distance and reduced current density on the cell. An increase in current density will increase the production on the cells.

The extra IR-drop (Interpolar Resistance drop) because of the gas bubbles in the electrolyte has been measured to be 0,15 – 0,35 volt in alumina reduction cells (1992, The 11th International Course on Process Metallurgy of Aluminium page 6-11).

There have been several proposals for minimizing the above mentioned problem, such as introducing anodes with a sloped or tilted bottom, forming slots or tracks in the wear surface of the anodes to drain said gas away from this area.

US 3438876 A describes a carbon anode applied in a Søderberg cell for aluminium production. The anode comprises plates of carbon (2) that are separated by plates of

2006259914 03 Aug 2010

2

aluminium (5). In the bottom of the anode the plates of carbon are individually separated by slots being 0,5 – 1,5 inches wide (12,7-38,1 mm).

US 2958641 A discloses a suspension arrangement for prebaked anodes. The anodes are clamped and suspended by steel plate casings. The anodes are arranged in a side by side arrangement, and between the anodes there is left a vertical space that is closed in the top by the bottom edge of the steel plate casings. The gas is drained towards the corners of the anode, which seems to have a substantially quadratic footprint. The gas above the bath is corrosive, and it is questionable if the steel casing will remain unaffected in operation, running a risk of getting contaminating metals in the aluminium metal produced.

Slots in prebaked anodes are normally produced in a vibrator compactor when the anode mass is in a green state, or in a dry milling process that is performed on the calcinated anodes. The dry milling process is normally performed by the use of a circular saw. In accordance with commonly available production methods of today, slots can be produced with a width that is approximately 13-15 mm.

There are some disadvantages having slots in the anode surface, and it will be mentioned here:

- Reduced anode life time in the cell because anode mass is removed
- Reduced anode working surface area
- Extra carbon material have to be transported back to the carbon mass factory (dry milling)
- Extra energy in the milling operation (dry milling)

All these drawbacks can be reduced by making the slots more narrow. Thus, the slots should not be wider than necessary to effectively drain the anode gases from the working surface.

A study carried out and reported in "R.Shekar, J.W.Evans, Physical modelling studies of electrolyte flow due to gas evolution and some aspects of bubble behaviour in advanced Hall cells, Part III. Predicting the performance of advanced Hall cells, Met.

and Mat. Trans., Vol. 27 B, Feb. 1996, pp. 19-27", indicates that tracks with a width less than 1 cm did not drain the gas properly.

Despite the teaching above, the applicant now has performed initial studies in an electrolysis cell applying anodes with very thin slots, which has proven to give sufficient gas drainage.

According to one aspect of the present invention, there is provided a method of producing aluminium in an Hall-Héroult cell with prebaked carbon anodes, where the anodes have at least one slot in its wear (bottom) surfaces for gas drainage, wherein the gas drainage is performed by at least one slot being 2-8 millimetres wide, where said slot is preferably cantilevered and extends from side to side at the bottom of said prebaked anode.

Preferably a method wherein the gas drainage is performed by at least two slots in each anode.

A method wherein the slots have a cantilevered bottom $>0^\circ$ and $<10^\circ$.

According to another aspect of the present invention, there is provided a prebaked anode for a Hall-Héroult cell for production of aluminium, the anode having at least one slot arranged in its bottom part (wear surface) for gas drainage, wherein said at least one of the slots are of 2-8 millimetres width and is preferably cantilevered and extends from side to side at the bottom of said prebaked anode.

Preferably, said at least one of the slots are of 3 millimetres width.

Preferably, the anode has at least two slots.

Preferably, the said at least one slot penetrates the anode to an extent that represents more than 50% of the anode height.

2006259914 03 Aug 2010

5 According to another aspect of the present invention, there is provided a prebaked anode for a Hall-Héroult cell for production of aluminium, the anode having at least one slot arranged in its bottom part (wear surface) for gas drainage, wherein said at least one slot are of 2-8 millimetres width and is preferably cantilevered and extends from side to side at the bottom of said prebaked anode.

0 Preferably, said at least one of the slots are of 3 millimetres width.

0 Preferably, the anode has at least two slots.

Preferably, the said at least one slot penetrates the anode to an extent that represents more than 50% of the anode height.

15 The anodes involved in the studies were calcinated and processed by implementing a processing technique known from processing/cutting other types of materials.

By making the slots in the calcinated anode thinner than that of the prior art, the above mentioned disadvantages will be less.

20

Since the thin slots take away only a small fraction of the anode mass, potentially a high number of slots can be used.

25 The drop in bath voltage when using slots allows amperage increase in the alumina reduction cell, increasing the production of aluminium and decreasing the specific energy consumption. This advantage is improved when using narrow slots, because of the earlier mentioned fact that only a small fraction of the anode mass is removed even when using several narrow slots.

30 These and further advantages can be achieved with the invention as defined in the accompanying set of claims.

03 Aug 2010

2006259914

3B

In the following, the invention shall be described further with reference to examples and figures where:

5 Fig. 1 discloses one sketch of one anode in accordance with the present invention.

Fig. 2 discloses bath voltage drop in alumina reduction cell versus number of slots.

Fig. 3 discloses a photo of one anode in accordance with the invention.

10 Fig. 4 discloses process data extracted from one full-scale study, applying anodes in accordance with the present invention.

15 As disclosed in Figure 1, there is shown an anode having slots processed into it and where the width of said slots are between 3 – 8 millimetres. Further, there are indicated two slots having a cantilevered bottom, where its depth at one end of the anode h2 is 320 millimetres and the depth at the other end h1 is 350 millimetres. The overall dimensions of the anode in this example is length, l=1510 millimetres, height h3=600 millimetres and width b=700 millimetres. Thus, the slots in this embodiment
20 extend through more than 50% of the height of the anode. The cantilevered bottom can be sloped corresponding to $>0^\circ$ and $<10^\circ$.

25 In Figure 2 is indicated how the bath voltage might decrease when an increasing number of slots is introduced in the anode. Actual numbers would vary with the anode width and length, the current density, and slot design. Voltage is indicated at the vertical axis, number of slots at the horizontal axis.

30 In the full-scale studies carried out, it has been observed that the depth of the slots will increase slightly due to the erosion in the electrolysis process. This effect is caused by the fact that the gas drained into the slots from the bottom of the anode will consume carbon

material in the bottom of the slot due to the Boudouard reaction ($\text{CO}_2 + \text{C} = 2\text{CO}$). A consumption of 2-3 centimetres of carbon material in the bottom of the slots has been observed in an anode that had been utilised in the cell for 17 days, i.e. 60% worn anode. This self-propelled slot extending effect must be taken into account when determining the processing depth of the slots.

By the new method of processing the slots, there will be produced fine-grained dust that can easily be returned back to the mass factory. In fact, the dust produced will replace a certain type of dry dust that is needed in the mass factory anyway. Thus, instead of having a problem with excessive material to be recycled, one now have production of useful material due to the new processing method.

Figure 3 discloses a photo of one anode in accordance with the present invention, showing the wear surface (the bottom side) of the anode. The anode has been removed from the cell after a period of production. The two longitudinal lines disclosed in the photo are the slots.

Fig. 4 discloses cell noise data, extracted from one full-scale study, applying anodes in accordance with the present invention. As shown in the Figure, it is possible to run the electrolysis process in a more stable manner than that of non-processed anodes.

The drop in voltage noise in the cell is at least the same as obtained earlier in cells having traditional slots of width of 12-15 millimetres, indicating that the 3 mm slot width is sufficient to remove the carbon dioxide gas from the working surface of the anode.

A further comparison between anodes with 3 millimetres wide slots and anodes with 15 millimetres wide slots shows that even with the same number of slots the advantage is considerable: For an anode of 100 cm width and provided with two 15 millimetres wide slots, the anode working surface was reduced by 3%. In an anode in accordance with the present invention, two slots of 3 millimetres width reduces the working surface by only 0,6%.

It is assumed that the invention will work with even more narrow slots, for instance 2 millimetres, but it has not been practically possible to verify that as of yet.

2006259914 03 Aug 2010

4A

Finally, it is to be understood that various alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the spirit or ambit of the invention.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of producing aluminium in an Hall-Héroult cell with prebaked carbon anodes, where the anodes have at least one slot in its wear (bottom) surfaces for gas drainage, wherein the gas drainage is performed by at least one slot being 2-8 millimetres wide, where said slot is preferably cantilevered and extends from side to side at the bottom of said prebaked anode.
2. A method in accordance with claim 1, wherein the gas drainage is performed by at least two slots in each anode.
3. A method in accordance with claim 1, wherein the slots have a cantilevered bottom $>0^\circ$ and $<10^\circ$.
4. A prebaked anode for a Hall-Héroult cell for production of aluminium, the anode having at least one slot arranged in its bottom part (wear surface) for gas drainage, wherein said at least one of the slots are of 2-8 millimetres width and is preferably cantilevered and extends from side to side at the bottom of said prebaked anode.
5. A prebaked anode in accordance with claim 4, wherein said at least one of the slots are of 3 millimetres width.
6. A prebaked anode in accordance with claim 4, wherein the anode has at least two slots.
7. A prebaked anode in accordance with claim 4, wherein the said at least one slot penetrates the anode to an extent that represents more than 50% of the anode height.
8. A prebaked anode in accordance with claim 4, wherein the said at least one slot is cantilevered at an angle between 0° and 10° .

2006259914 03 Aug 2010

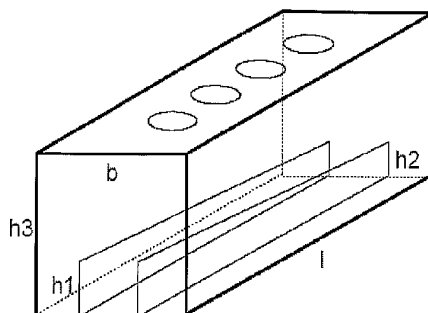
5

6

9. A method of producing aluminium in a Hall-Héroult cell with prebaked carbon anodes substantially as herein described with reference to the accompanying drawings.
10. A prebaked anode for a Hall-Héroult cell for production of aluminium substantially as herein described with reference to the accompanying drawings.

1/3

h1 = 350 mm
h2 = 320 mm
slot width = 3 - 8 mm
l = 1510 mm
h3 = 600 mm
b = 700 mm

**Fig. 1**

2/3

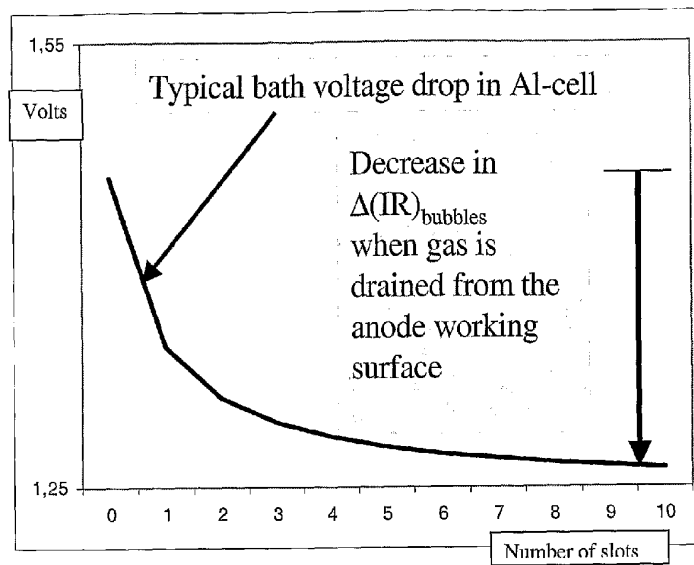
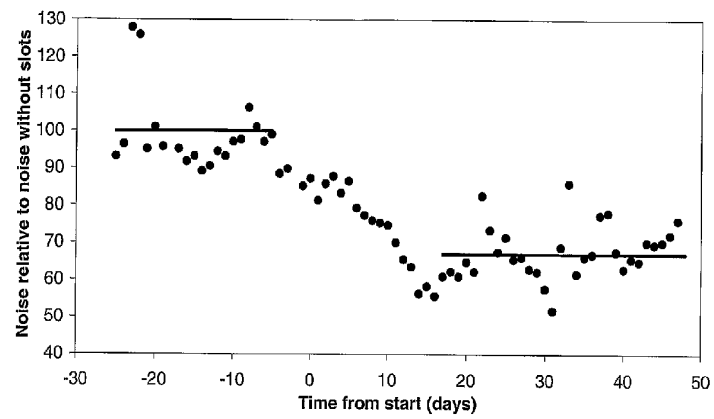


Fig. 2



Fig. 3

3/3

Fig. 4