Essential Readings in Light Metals: Electrode Technology for Aluminum Production.
Edited by Alan Tomsett and John Johnson.
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THE EFFECT OF PREBAKE ANODE BAKING TEMPERATURE ON POTROOM PERFORMANCE

G. A. Bain
J. P. Pruneau
J. Williams

Abstract

An experiment was carried out to evaluate the effect of anode baking temperature on potroom performance in 65 kA prebake pots. Twelve pots were operated with anodes baked to 1200°C; twelve pots were operated with anodes baked to 1050°C and twelve pots were operated with regular production. Individual tapping weights for each pot were measured and recorded. Carbon consumption was obtained by weighing the anodes and all the butts. Results indicate a decrease in anode consumption of 2.7% and an increase in current efficiency of 0.6% per 100°C increase in baking temperature.

G. A. Bain is staff development engineer, Reduction Development Department, Aluminum Company of Canada Ltd., Arvida, Quebec.

J. P. Pruneau is development engineer, Reduction Development Department, Aluminum Company of Canada Ltd., Arvida, Quebec.

J. Williams is process analyst, Carbon Plant, Aluminum Company of Canada Ltd., Arvida, Quebec.

INTRODUCTION

Many investigations carried out over the past ten years by different companies have suggested that a decrease in anode consumption and an increase in potroom current efficiency could be obtained by baking anodes to a higher temperature. Decrease in anode consumption of 1% to 10% and increase of 0.5% to 4.0% in current efficiency per 100°C increase in baking temperature have been claimed.[1][2][3][4]

To determine what particular increases in efficiency would be applicable in our prebake lines, it was decided to run a full-scale test.

DESCRIPTION OF THE TEST

The test was run in 65 kA prebake pots. Each pot has 18, 32" x 20" x 24" anodes. Petroleum coke calcined to a real density of 2.05 g/cc is ground and mixed with 16.5% of 105° C/A softening point pitch. The anodes are formed by a hydraulic press and baked in Horizontal Flue Ring Furnace[5]. These Ring Furnaces have 7 or 8 pits per section and 64 or 80 sections. The furnace is fired with bunker "C" oil and a 240-hour baking cycle was used. The flue walls have only one baffle down the middle. The pits are 9'-4 1/2" long by 10'-4 1/2" high and 38'-3/4" wide. After baking and rodding with cast iron, the anodes are mantled to help prevent oxidation.

Method of Selecting Anodes by Using Ring Furnace Temperature Profile

The test involved selecting 1200 anodes from the Ring Furnace for each of the three baking temperature levels which were: 1200°C ± 50°C, 1050°C ± 50°C and a mixture of these temperatures chosen at random.

The selection of anodes for the test was based on an average temperature profile for a Ring Furnace pit. This was determined from twelve (12) pits selected at random at the beginning of the test. In each pit, 24 points were measured as shown in Figure 1, page 8. Anode temperatures were calculated by taking the average of two values e.g. 1/2 (A+B) or 1/2 (D+E). The deviation of each anode position from the average anode was calculated for each pit. An average deviation for a position was then calculated and this is shown in Figure 2, page 9 . These values give the average profile on which selection of anodes was based. In addition, the standard deviation of the average deviation was calculated to give an idea of the areas in a pit which are less consistent. As seen in Figure 2, the top row of anode is particularly bad. This factor was incorporated into the selection procedure.

Selection of Anodes at each Level

Step No. 1 For each pit, the temperature of the average, maximum and minimum points, was measured after firing.

Step No. 2 If the range (i.e. maximum - minimum) is between 150°C and 300°C then that pit is acceptable. This ensures that the average profile values will be applicable.

Step No. 3 The estimated temperature of all the other anodes in the pit is determined by using the deviation from the average anode (i.e. average profile in Figure 2).

Step No. 4 The anodes which fall within the limits i.e. 1050°C ± 50°C and 1200°C ± 50°C are pinpointed but before they are selected as test anodes they must pass a further test (described in step No. 5) designed to increase our confidence that the anode is actually between the limits set above.

Step No. 5 The appropriate standard deviation is taken from Figure 2, and both added to and subtracted from the actual temperature. Both answers must lie between 1050°C ± 50°C and 1200°C ± 50°C.

This is illustrated below with an example.

Example

We want to determine if anode position 8 is acceptable for the test.

The average anode temperature after firing was 1010°C.

The average deviation for position 8 is +24°C. The estimated temperature of that anode is then: 1010°C + 24°C = 1034°C.

The standard deviation for this anode position is ± 25°C

Subtracting	1034°C - 25°C = 1009°C
This is between	1050°C ± 50°C
Adding	1034°C + 25°C = 1059°C
This is also between	1050°C ± 50°C

Since both answers are between 1050°C ± 50°C, this anode is accepted.

Determination of Anode Consumption

Anodes fitting the test requirements were marked and regular anodes were chosen at random. All the anodes were weighed, the weight, group identification and a code number were painted on the anodes before they were piled in their appropriate piles. Each day approximately 30 anodes of each type from the piles were rodded. The group identification and code number were painted on each rod before the anodes were mantled. This information was entered in a data book.

The code number was used to record the anode weight, the anode butt dimensions (length, width and height) the butt weight and other pertinent data. The anodes were mantled and sent to the 65 kA pots as required.

When all the anodes of the 36, 65 kA pots had been replaced by "test" anodes and these had completed their cycle, the weighing of the butts was started. All the butts were weighed after scraping off the bath. The dimensions of the anode butt, depth of oxidation of the carbon at the stud, thickness of carbon between the stud and the bottom of the butt were determined and entered in the data book under the appropriate code number. The butts were removed from each rod and weighed. The butt weight was entered in the data book under the appropriate code number.

Determination of Current Efficiency

Three groups of twelve pots were chosen at random: one group operated with anodes baked to 1200°C ± 50°C, a second group with anodes baked to 1050°C ± 50°C and the third group with regular anodes, i.e. a mixture of baking temperature chosen at random.

Technicians working on three shifts were responsible for the anode changing, tapping follow-up and data collection.

The anodes of the 36 pots of the experiment were replaced by "test" anodes following the normal anode changing schedule. On each shift, technician recorded the pot number, position of the anode changed, group identification and code number of all the anodes installed during the shift.

When all the anodes of the 36 pots had been replaced by test anodes the technicians also recorded the group identification and code number of the anode butt. When an anode was replaced ahead of schedule, the pot number, group identification and code number, were recorded.

In order to obtain current efficiency, the weight of each tapping for each pot was taken by the technicians. The amperage of the line, daily average gross voltage and daily anode effect number for each pot were collected. The bath temperature of each pot was taken twice a week.

RESULTS

Qualitative Results

Table I, page 4, gives the number of anodes changed before schedule as a percentage of the total number of anodes.

TABLE I

PERCENT OF ANODES CHANGED BEFORE SCHEDULE

	First Cycle	Second Cycle	Third Cycle	Fourth Cycle	Fifth Cycle	Average
Anodes Baked to 1200°C ± 50°C	7.5%	10.5%	10%	8.5%	6.5%	8.5%
Anodes Baked to 1050°C ± 50°C	14.5%	16%	15%	7%	12%	13%
Regular Anodes	7.5%	6%	9%	10%	16%	9.5%

The increase in baking temperature from 1050°C to 1200°C reduces the number of anodes changed before schedule by 4.5%.

Anode Consumption

The anode consumption in lb C/kAh for four cycles is reported below.

TABLE II

ANODE CONSUMPTION AS A FUNCTION OF BAKING TEMPERATURE AND TEST CYCLE

Anode Baking Temperature Level	First Cycle	Second Cycle	Third Cycle	Fourth Cycle
Pots operating on anodes baked to 1200°C ± 50°C	0.305	0.302	0.304	0.315
Pots operating on anodes baked to 1050°C ± 50°C	0.317	0.317	0.318	0.326
Pots operating on regular anodes	0.308	0.313	0.310	0.320

Using the individual pot averages for the four cycles combined, gives the following consumption (12 pots vs. 12 pots for 4 cycles).

Consumption anodes baked to 1200°C ± 50°C	0.306 lb C/kAh
Consumption anodes baked to 1050°C ± 50°C	0.319 lb C/kAh
Consumption regular production a mixture of baking temperature chosen at random	0.312 lb C/kAh

The increase in baking temperature from 1050°C to 1200°C decreases the anode consumption by 4.1%.

Current Efficiency

The current efficiency along with the pot voltage, bath temperature and anode effects for the duration of the test is given below.

TABLE III

POT OPERATING CHARACTERISTICS AS A FUNCTION OF ANODE BAKING TEMPERATURE

Anode Baking Temperature Level	Current Efficiency	Pot Voltage	Bath Temperature		Anode Effects	
	difference from the average	difference from the average	°C	Std. Dev.	No./pot-day	Std. Dev.
1200°C ± 50°C	+ 0.1%	no difference	978	3	0.8	0.2
1050°C ± 50°C	- 0.8%	no difference	980	3	0.8	0.2
Regular anodes	average	average	979	3	0.8	0.3

The difference in current efficiency is 0.6 ± 0.8% (95% confidence limits) per 100°C difference in baking temperature.

DISCUSSION

Carbon Consumption

The effect of anode baking temperature on carbon consumption shows the same general trend as has been previously reported. The rate of decrease with increase in baking temperature lies within the range previously reported. Table IV compares our data with those which have been published.

TABLE IV

COMPARISON OF REPORTED RESULTS ON THE RELATIONSHIP BETWEEN BAKING TEMPERATURE AND CONSUMPTION

Anode type and source	Baking temperature °C	Anode consumption lb /kAh	Decrease in anode consumption / 100°C increase in baking temperature
Prebaked - Pechiney (1)	950- 1230	0.274-0267	0.9%
Prebaked - Ormet (2)	<1000->1100	0.347-0.313	10%
Prebaked - Arvida 65 kA pot	1050- 1200	0.319-0.306	2.7%

Values for pounds of carbon consumption per kAh should not be compared since the size of the anode, whether or not it is mantled, the cell design, the aggregate used and other such features, can markedly affect the value. Different systems of reporting carbon consumption may also influence the results.

It would appear, however, that a valid comparison on the rate of change in anode consumption with baking temperature can be made. In the case of the Pechiney study, the rate of decrease is substantially less than that shown for Alcan. No explanation for the difference is apparent. Ormet report a very substantial change in consumption with temperature. However, the temperature of baking of their anodes does not appear to be precisely defined and it may be that the true difference in temperature of the anodes was closer to 300° rather than the minimum 100° shown in their report.

Current Efficiency

The effect of anode baking temperature on current efficiency is not as clear cut as it was on anode consumption. We found an increase in current efficiency of 0.6% ± 0.8% per 100°C increase in baking temperature. This is less than previously quoted values(1) (2). Table V compares our results with those previously reported.

TABLE V

REPORTED RELATIONSHIPS BETWEEN CURRENT EFFICIENCY, ANODE CONSUMPTION AND BAKING TEMPERATURE

Anode Type and Source	Baking Temperature	Increase in Current Efficiency	Increase in Efficiency/ 0.01 lb /kAh	Increase in C.E./ 100°C increase in Baking Temperature
Prebaked - Pechiney	950 - 1230	5	7	1.25
Prebaked - Ormet	<1000 - >1100	4	1.2	1.33
Prebaked - Arvida 65 kA Pot	1050 - 1200	0.9	0.7	0.6

The last two columns of the table are attempts to make comparisons between the data on the basis of the change in reported temperature and also on the basis of the change in reported carbon consumption. As far as the change in current efficiency with change in carbon consumption is concerned, the results compare poorly. In the last column, an attempt has been made to calculate the change in carbon consumption per 100°C change in carbon baking temperature. In this case, we have assumed that the Ormet values represented a true spread of approximately 300° rather than the minimum 100° difference shown. If this is admitted as a valid technique, it can be seen that the change in current efficiency per change of 100° in baking temperature averages out to about 1%, and this may be the best value to use in any future calculations.

General

There is one interesting feature of the results which cannot be explained; although on carbon consumption, the regular anodes fall exactly halfway in between the 1050°C and 1200°C baked anodes, when we compare results for current efficiency and anodes changed before schedule, we find that the regular anode behaviour is much closer to that of the 1200° baked anodes than to the 1050°. We can offer no explanation other than statistical variation for this apparent anomaly.

It might also be noted that operating temperature of the pots follows the expected trend, with the average value being for the regular anode, and lying halfway between the other two. This fact is further support for the hypothesis of linearity stated above.

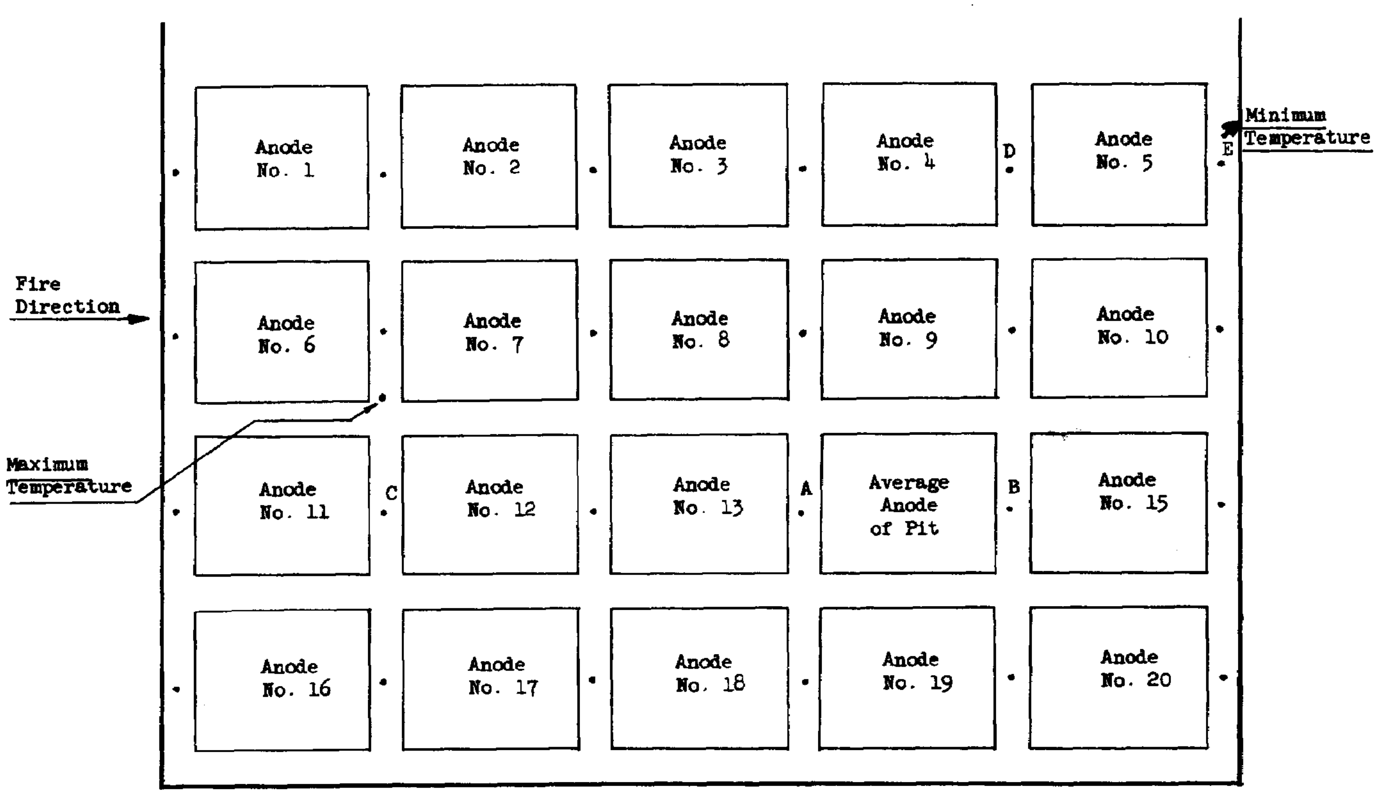
FIGURE 2

AVERAGE DEVIATION AND STANDARD DEVIATION FOR A POSITION

- 12°C ± 47°C	+ 11°C ± 41°C	- 35°C ± 33°C	- 95°C ± 19°C	-142°C ± 42°C
+ 69°C ± 32°C	+ 77°C ± 20°C	+ 24°C ± 25°C	- 33°C ± 14°C	-101°C ± 18°C
+ 79°C ± 16°C	+ 92°C ± 24°C	+ 61°C ± 14°C	0	- 78°C ± 21°C
+ 36°C ± 18°C	+ 51°C ± 28°C	+ 30°C ± 22°C	- 29°C ± 18°C	-122°C ± 13°C

FIGURE 1

POSITION OF THERMOCOUPLES FOR TEMPERATURE MEASUREMENT AND PIT PROFILE



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