INVESTIGATION OF THE QUALITY OF RECYCLED ANODE BUTTS

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ABSTRACT

Anode butts are recycled and used together with petroleum coke and pitch for the manufacture of anodes. The quality of these butts has a strong influence on the properties of the anodes.

For this reason butts of different origins were examined to ascertain what makes a good butt. It was ascertained that good butts are hard, have low sodium contents, a high ignition temperature in air and low reactivities in CO2 and air. Butts of bad quality are soft and very reactive. The butt quality was defined by measuring the physical properties and the contaminations of the butts.

INTRODUCTION

In the electrolytic production of aluminium from alumina, carbon anodes are needed. Large anodes reach sizes of 1.65 * 1.0 * 0.65 m3. They are in the reduction pot for 24 to 30 days, but cannot be fully consumed there. The mechanical suspension of the anode and the current supply make it necessary to remove the butt, which can be 15 to 30 % of the initial weight of the anode at the end of the pattern days. These anode butts are cleaned of any adhering particles of electrolyte - the latter consists of a mixture of cryolite, AlF3 and other fluorides - and are then recycled for the production of new anodes. The dry aggregate in anode fabrication mainly consists of petroleum coke, 0 to 30 % anode butts in granulated form are added to the dry aggregate. Anodes made from 100 % anode butts in the dry aggregate have also been produced and successfully used in the potroom.

The properties of the petroleum coke essentially determine the quality of the anodes produced. Every anode producer endeavours, therefore, to use good and suitable petroleum cookes and subjects them to a quality control, in which the relevant physical and chemical properties are determined (1).

Because of the fact that the anode butts are re-used, their quality features are also of great importance. It was found that when poorly cleaned or soft anode butts are used, the anode quality suffers considerably.

The butt quality and its influence on the anode quality have been examined, therefore; this will be described in the following sequence:

- behaviour of the anodes in the reduction pot
- assessment of anode butts after anode changing
- properties of butt granulates
- crushed butts of good quality
- crushed butts of poor quality
- poorly cleaned butts
- properties of test cylinders of good and poor butts
- influence of good and poor butts on the quality of the anodes.

BEHAVIOUR OF THE ANODES IN THE REDUCTION POT

An anode is set with ambient temperature in the 930 - 980°C hot electrolyte. 25 to 50 % of the lower part of the anode is thus immersed in the liquid bath melt. Depending on the pot design, the part of the anode which is out of the bath is covered more or less with granulated electrolyte material and/or alumina. There are pots in which parts of the anode do not have any protective cover at all for many days.

The anode temperature rises by heat being conducted out of the electrolyte and by the current flow. The temperatures reach 350 - 600°C on the upper parts of the anodes after 1 - 3 days. Depending on the protective effect of the cover, airburn sets in at the upper part of the anode; this airburn represents non-electrolytic or excess carbon consumption.

With current flow, the electrolytic consumption begins on the immersed part of the anode; it amounts to 350 - 380 gC/kGaAl and causes a loss in height at the lower part of the anode of 1.4 to 1.7 cm/day. Due to the electrolytic decomposition of the Al2O3 the oxygen, which is released, combines with the carbon of the anode to CO2 and CO. CO2 now attacks the anode; CO burn develops, which also means non-electrolytic carbon consumption.

Non-electrolytic and electrolytic consumption together give the net consumption (2). It amounts to 390 - 450 gC/kGaAl; the non-electrolytic consumption
ments to 10 - 30 % of the electrolytic consumption, therefore.

CO₂ and air oxygen normally attack the anode selectively (3). That means that the binder coke is attacked and consumed earlier and faster than the grains of the dry aggregate. They lose their mechanical bond with the anode and drop into the electrolyte as carbon granulate (carbon dust). In this way the electrolyte temperature can increase sharply so that above all the airburn and with it the carbon dust formation increase exponentially.

CO₂ mainly attacks the lower part of the anode, which is subsequently consumed by the electrolysis. The situation is a different one for the airburn. The airburn begins when the ignition temperature is reached and now has many days' time until the upper part of the anode has disappeared below the protective covering layer of electrolyte and alumina.

The airburn is now unfortunately not a reaction which only takes place on the surface of the anode. The air oxygen penetrates, due to gas permeability and open porosity, a few centimetres into the interior of the anode and reacts selectively there too, with the carbon. The result is that the anode structure is also mechanically weakened on the inside.

If this damaged part becomes electrolytically active at the end of the pattern days, the CO₂ attack continues its destructive effect. The anode butt which is taken out at the end is soft and only has a small butt cross-section.

If a lot of carbon dust is swimming on the electrolyte, then it represents, due to the combustion, an ideal and plentiful supply of CO₂. The upper part of the anode is then additionally considerably attacked by this in the last few pattern days. This can lead to small and soft butts, even when the quality of the anodes was good, until the carbon dust has been removed from the bath.

Soft butts are, therefore, not inevitably due to poor anode quality. If the electrolyte temperatures are high for other reasons, the airburn will increase considerably as a result and again lead to soft butts with small butt cross-sections.

ASSESSMENT OF ANODE BUTTS AFTER ANODE CHANGING

The assessment of the anode butts by the pot-room personnel is done by measuring the average butt cross-section and the degree of softness.

The degree of softness can be objectively determined with a measuring device which has been developed and tested by the authors (Fig. 1). The measuring device is placed on the anode butt. Two pins are turned circularly and penetrate the butt until the hard core is reached (Fig. 2). The depth of penetration (mm, measured in semi-turns of the spindle) determines the degree of softness of the anode butts.

The quality assessment which can be carried out after removing the butts from the pots, can be classified according to Table 1 as follows:

<table>
<thead>
<tr>
<th>Butt Quality</th>
<th>Good</th>
<th>Medium</th>
<th>Poor (soft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butt cross-section (%)</td>
<td>&gt; 90</td>
<td>85 - 90</td>
<td>&lt; 85</td>
</tr>
<tr>
<td>Penetration depth (mm)</td>
<td>0 - 2</td>
<td>3 - 5</td>
<td>&gt; 5</td>
</tr>
</tbody>
</table>

Table 1: Assessment of the quality of anode butts after their removal from the reduction pot

Figs. 3 and 4 show good or poor anode butts.

PHYSICAL AND CHEMICAL PROPERTIES OF ANODE BUTTS

Introduction

Anode butts are crushed and fractioned after cleaning. They then become a part of the dry aggregate for anode fabrication just like petroleum coke. The obvious procedure is, therefore, to subject anode butts to the same measurements as the petroleum cokes. In addition test cylinders can be taken from the butts as from the anodes. A test scheme can then be applied to them as in the case of the prebaked anodes (1,4).

Basically and logically those anode butts are best, which do not differ or differ as little as possible from good coke or good anodes.

A certain increase in the contaminations cannot be avoided even if the butts are properly cleaned.

In the following these butt properties are examined for different qualities of butts. The qualitative selection of the butts took place according to the criteria of Table 1.

Examinations of Fractions of Crushed Butts of Good Quality:

For the following considerations it will suffice to look at the average properties of crushed and then screened butts. The analysis results on granulates of good, hard and poor, soft butts are shown. Both butt populations are summarised in Table 2. The following statements regarding the data relevant to burning can be made from this table:

- Good butts are similar to coke.
- Compared to coke, above all the two reactivities and the ignition temperature deteriorate in butts.
- Table 2 and the Tables 3 to 5 shown later contain analysis data. The typical data of similar materials are in a range around the data indicated.