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INTERDEPENDENCE BETWEEN PROPERTIES OF ANODE BUTTS AND QUALITY OF PREBAKED ANODES

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ABSTRACT

Prebaked anodes contain about 50 to 65 % petroleum coke, 14 to 17 % coal tar pitch and 15 to 30 % recycled anode butts. It is well known that the amount and cleanliness of the butts influence anode physical properties such as the mechanical strength and permeability as well as the carboxy reactivity behaviour. Recent research work has shown a tremendous influence of butt's hardness on the physical properties and air reacitivity behaviour of prebaked anodes.

PROPERTIES OF HARD AND SOFT BUTTS

Over a period of 10 months, about 2000 anode butts taken from four different smelters were sampled and tested according to the test schedule shown in Figure 1.

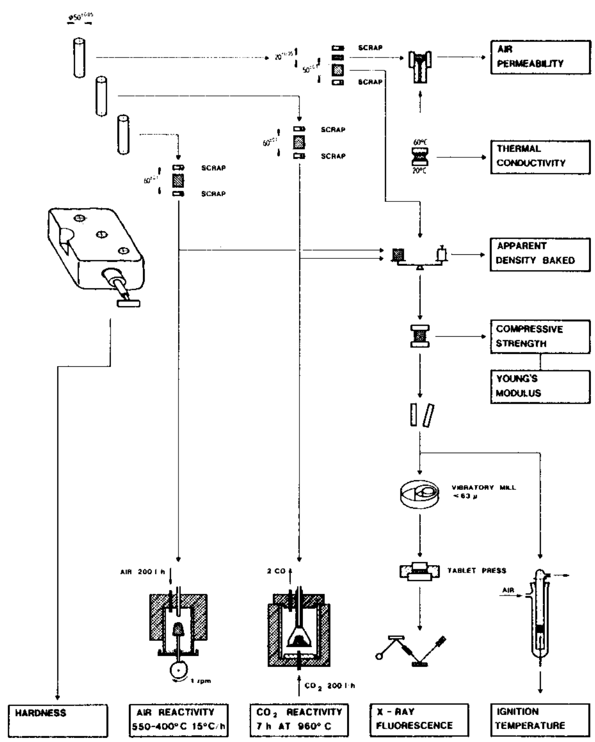

Figure 1. Test schedule for anode butts.

The test schedule for anode butts is based on the standard test methods for prebaked anodes (1). Also included is the determination of the hardness of the butts by a steel rod penetration method (2) and of the ignition temperature (3) on crushed granular material. These two methods were introduced, because recent research work has shown the huge influence of soft butts on the physical properties of anodes and a strong interdependence between the ignition temperature of the butts and the air burn behaviour of the anodes.

Table 1 shows the average quality figures of 200 samples taken out of the initial anode populations and the 25 % hardest and softest of the 2000 tested butt samples. This selection was based on measurement of the compressive strength although it could equally have been made with the hardness tester, the difference in the impact being about one order of magnitude.

PROPERTIES		UNIT	AVERAGES OF THE SAMPLES		
			200 ANODES	500 (25 %) HARDEST BUTTS	500 (25 %) SOFTEST BUTTS
HARDNESS TEST IMPACT		mm	0.2	1	10
APPARENT DENSITY		kg/dm3	1.57	1.54	1.48
COMPRESSIVE STRENGTH		MPa	42	37	16
YOUNG'S MODULUS		GPa	5	4	1.5
THERMAL CONDUCTIVITY		W/mK	3.8	3.7	3.2
AIR PERMEABILITY		nPm	1	2	8
CO2 REACTIVITY RESIDUE		%	90	87	81
AIR REACTIVITY RESIDUE		%	82	78	65
IGNITION TEMPERATURE		°C	620	610	560
ELEMENTS	S	%	1.45	1.45	1.45
	V	ppm	110	110	115
	Fe	ppm	220	230	270
	Na	ppm	300	600	500
	Ca	ppm	50	80	70
	F	ppm	100	900	750

Table I. Average properties of 2000 butt samples compared with those of the initial anodes.

The purity (S,V) shown in this table confirms that the raw material composition was very constant. Comparing the other properties it is evident that hard butts are almost identical to the original anode quality whereas soft butts have a lower apparent density. This is indicative of a substantial increase in porosity which leads to much poorer mechanical strength, higher elasticity, lower thermal conductivity and of course to an extremely high level of permeability. Air and CO_2 reactivity residues are also deleteriously affected by this porosity increase and the ignition temperature shows a measure decrease of 60 °C.

The increase of bath components in butts is due to two different mechanisms. The dirtier surface of hard butts, due to the sticking of a bath skin (0.5 – 1 mm thick), is shown on the right of the Figure 2.

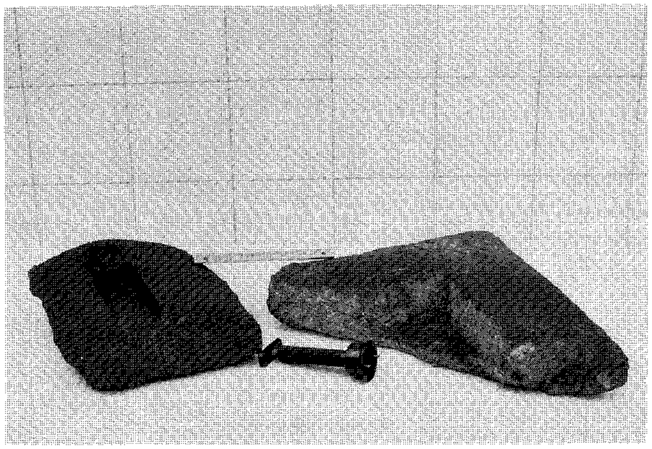

Figure 2. Soft and hard anode butts.

With efficient cleaning of soft and hard butts, an overall sodium content below 1000 ppm can be reached. The second reason for bath presence in butts is impregnation (up to 3 % Na content). During recent years smelters having up to 30 % of impregnated butts were observed. There were no significant differences seen made between the impregnation extent of soft and hard butts. In most of the cases, the impregnation was due to a cathodic charge during the pattern days of the anode. Such cathodic connections happen due to a slideslip of the anodes, due to a too low anode butt position during the removal or due to an interruption of the pot line current.

INFLUENCE OF THE BUTTS ON THE PROPERTIES OF ANODES

Influence of the Amount and Kind of Butts on the Density of Baked Anodes

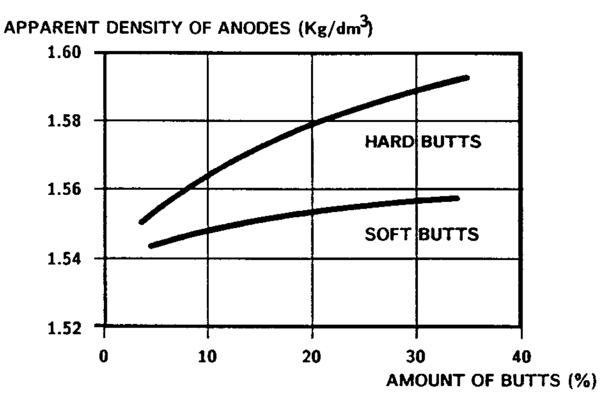

Figure 3.

The greater the quantity of dense butts material added as anode coarse fraction the higher the anode apparent density. This effect is much less evident for soft butts, which have been attacked by oxidant gas and are subsequently more porous.

Influence of the Amount of Butts on the Air Permeability of Anodes

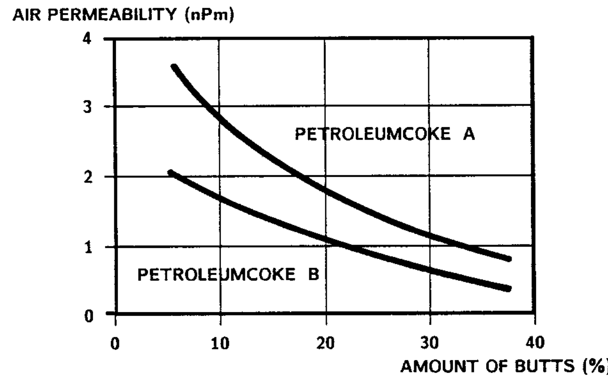

Figure 4.

The addition of increasing amounts of dense butts material will reduce the air permeability. This effect is more pronounced when using light coke (petroleum coke A) and underlines the risk of manufacturing high purity anodes without butts addition.

Influence of Hard and Soft Butts on the Mechanical Strength of Anodes

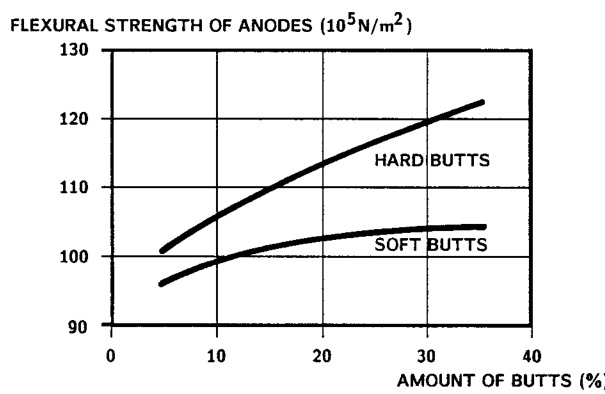

Figure 5.

Increasing the amount of hard butts material will improve the flexural strength of the anode. However, soft butts, being lighter and more porous show a much less dramatic influence.

Influence of the Sodium Content of Butts on the CO_2 Reactivity of Anodes

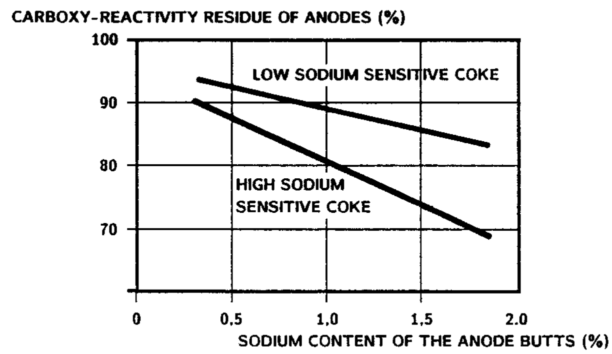

Figure 6.

Greater amounts of sodium in the form of cryolite introduced into the recipe through butts recycling will have a deleterious effect on carboxy reactivity residue. The magnitude of this effect will depend on the sodium sensitivity of the coke (4). This influence of the butts sodium content underlines the importance of having an efficient butts cleaning system.

Influence of the Ignition Temperature of Butts on the Air Reacitivity of Anodes

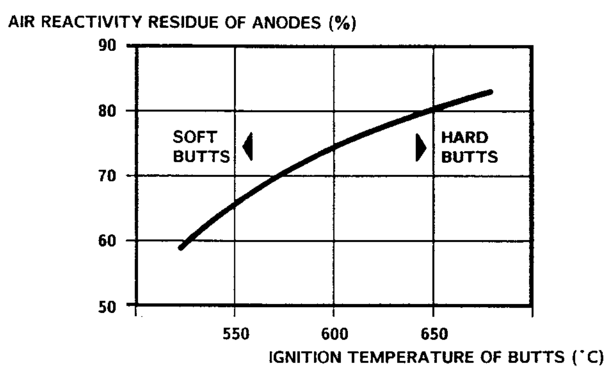

Figure 7.

The higher the ignition temperature of the recycled butts the better will be the air reactivity residue of the anodes. A high ignition temperature is indicative of hard butts that have been minimally attacked in the electrolysis cell. Soft butts, on the other hand, show much lower ignition temperatures due to their porous nature resulting from former CO_2 burn and airburn during the electrolysis. In the worst cases, attack of the soft butts grains will occur preferentially to selective burning of the binder matrix (Figure 8). Due to the exothermic nature of the airburn reaction a very rapid attack is observed.

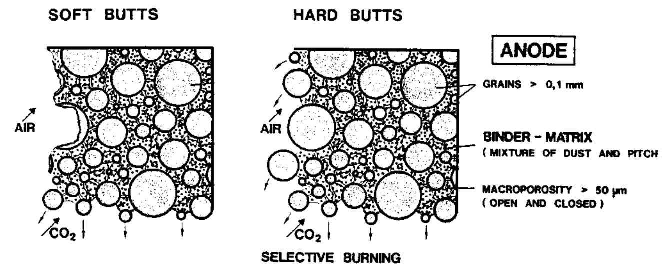

Figure 8. Influence of addition of soft and hard butts on the selective burning of anodes.

Addition of soft butts to the anode recipe further leads to softer butts with lower ignition temperature (vicious circle!) and after about 3 to 4 cycles, the airburn becomes so strong (rusty butts!), that 10 – 30 % burnoff as well as attack of the stubs results. Figure 9 shows such a heavily air burn attacked anode after 6 of 24 pattern days.

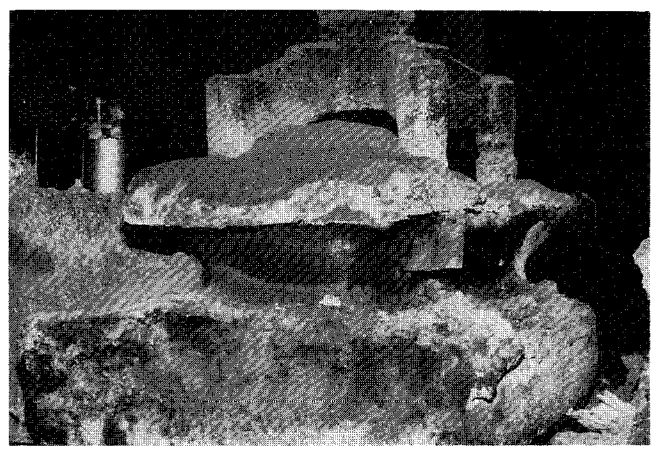

Figure 9. Air burn attacked anode.

FURTHER DEVELOPMENT

Different theories concerning the initial process of soft butts formation are currently being checked.

- Raw materials
- Underpitching
- Dust fineness, amount of dust
- Permeability
- Baking conditions
- Pot operating parameters

With a systematic monitoring of anode and butt properties as well as electrolysis conditions a quantitative statement should be possible.

SUMMARY

The following table shows the influence of the butt quality on the anode properties.

INFLUENCE OF BUTT QUALITY ON ANODE PROPERTIES (BUTT CATEGORIES)	HARD CLEAN	HARD DIRTY	SOFT CLEAN	SOFT DIRTY
APPARENT DENSITY	++	++	+	+
MECHANICAL STRENGTH	++	++	+	+
PERMEABILITY	++	++		
CO2 REACTIVITY RESIDUE		–	–	––
AIR REACTIVITY RESIDUE		–	––	–––
IGNITION TEMPERATURE		–	––	–––
PURITY	–	––	–	––

INFLUENCE	
++	VERY POSITIVE
+	POSITIVE
	NEUTRAL
–	NEGATIVE
––	VERY NEGATIVE
–––	CATASTROPHIC

Table II. Influence of butt quality on anode properties.

Hard, clean butts, added as the coarse fraction are an excellent raw material. The use of soft, dirty butts deleteriously influence the burning behaviour of the anodes and create, due to a vicious circle, softer and softer butts and an extreme amount of carbon foam in the electrolysis pot. In such a catastrophic situation, both a daily skimming of the pots and a complete stoppage of butts addition to the anode recipe over several months are recommended.

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