Short payback times when using slotted anodes

When the latest generation of automatic slot-cutting machines manufactured by T.T. Tomorrow Technology are used, the quick delivery time and trouble-free implementation ensure that payback times are short

The aluminium industry has been achieving a headlong development for some decades. The use of the best technologies available has resulted in strategic advantages, which have ensured greater productivity and a better use of energy resources. In recent years environmental concerns have coincided with a weakening of aluminium prices. The achievement of energy efficiency targets has made it possible to reduce specific energy consumptions and has thus contributed to both energy conservation and the reduction of operating costs.

Anodes play a very important role in the achievement of optimum electrical performance in aluminium electrolysis cells. The dimensions and physical properties of the anodes are vital factors, each of which can affect performance positively or negatively depending on how they are managed.

In both new, greenfield smelters built using up-to-date technology and old smelters which have been in operation for a long time and are often affected by structural constraints, the use of slotted anodes overcomes serious problems and thus enhances performance and results in economic and production improvements.

As is well known, carbon anodes are produced by mixing, moulding and baking calcined petroleum coke and pitch. Anode dimensions are extremely important for enhancing cell productivity, and anode density is also important for the achievement of good production performance and efficiency. A common approach is to increase the dimensions of the anodes, but unfortunately this can result in higher cell resistance owing to the accumulation of gas bubbles under the bottom surface of the anodes. Moreover, anodes with a lower or non-uniform density have an adverse effect on production and thus on the economics of the electrolysis process.

An effective way to allow the gas that forms continuously during the electrolysis process to escape, and thereby to reduce or eliminate the accumulation of gas bubbles under the anodes (this, as implied above, being a function of anode size), is to form slots in the bottom surface of the anodes. The major benefits of using slotted anodes are reduced cell resistance and improved cell stability. The depth of the slots is important for ensuring that these benefits last throughout the life of the anodes ('full-life slots'), while slot shape, which determines the gas escape direction and related areas of influence, is also important for achieving further pot management benefits.

Traditionally, there are two ways to introduce slots into anodes: the slots are either formed in green anodes by using special moulds in the anode vibro-compactor, or are cut into the anodes after the baking process.

The first method appears at first sight cheaper but is in fact only apparently so, because it results in a higher proportion of anode discards due to unsatisfactory quality before the anodes are fitted into the cells, and also has intrinsic dimension-related limits (short and wide slots reduce current density and limit slot life in the cells). Furthermore, the physical characteristics of the anodes are inferior and non-homogeneous.

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The second method – cutting slots into the anodes after the baking process – overcomes the limits and disadvantages of slots formed during vibro-compaction.

T.T. Tomorrow Technology, located in Padua, Italy, has acquired particular knowledge in the field of manufacturing equipment for cutting (slotting) anodes. In-house R&D and long experience in the design and production of dedicated equipment for cutting and slotting anodes, as well as handling the carbon, have formed the basis for developing the latest generation of automatic slot-cutting machines. In the last twelve months the company has supplied and successfully commissioned four new anode slotting lines. Each of these was characterized by a shorter supply lead time between the contract award and the start of production at the client, and by a short payback time.

Typical RoI (Return on Investment) calculations for the installation of a new anode slotting line in a smelter with production capacity of the order of 300,000 tonnes of aluminium per year yield a result ranging from seven to twelve months.

Short payback times (which can be considered to be those of less than one year) are harder to achieve in units with a 'small' production capacity, and for that reason the above-mentioned RoI times for smelters with more modest production capacities does indeed represent a substantially profitable investment.

It is relatively easy to estimate the economic benefits deriving from the use of slotted anodes. The major benefits achieved, which have a direct impact on the smelter's economics, are: a) energy is saved and b) production is boosted: more aluminium is produced by increasing the line current while keeping the original voltage the same; in an alternative approach, the result of a larger voltage drop is to reduce energy costs or to increase current so that the original energy input is maintained.

There is no doubt that the values involved vary, depending on a number of plant-specific factors. These include anode quality and related properties, which play an important role. However, slot depth has a direct impact on the specific benefits of slotting, since the total benefits accruing depend directly on slot depth. This is often a deciding factor when a smelter changes from the short and wide slots formed by moulding the green anodes, to the deeper and narrower slots cut after the anodes have been baked.

The recognized benchmark is now to have slots whose depth is such as to prolong their positive effects during the entire life of the anodes.

Anode slotting machines have often been installed where previously the slots were formed in the green anodes. The table summarizes a brief comparison of the characteristics of each type.

It is easy to show by calculation that the weight of carbon lost, with slots formed in the green anodes, is much higher that the carbon loss when anodes are slotted after baking. For slots of the same depth, the carbon loss from anodes whose slots are moulded while green can be up to three times the loss when

	Slots formed in a green anode	Slots cut into a baked anode
Orientation	Determined by anode ejection direction from the mould	No restriction
Slot width (mm)	40 (at base) to 20 (at top)	8 – 10 – 12 (constant)
Slot depth (mm)	150 to 300 mm (typical)	Up to 450 mm with 12 mm width
Anode density	Not homogeneous (affected by the inserts used to form the slots	Higher, and homogeneous (not affected by the presence of the slots)

the slots are cut into baked anodes. The impact on cell performance and management is therefore considerably in favour of the second alternative, which in addition is exempt from density-related problems.

Compared with anodes having slots moulded while green, slots cut into baked anodes help to reduce carbon consumption since the typical disadvantages of the former type are avoided. In particular, CO and CO_2 attack is more pronounced in 'green' anodes due to their lower apparent density and greater air permeability.

Besides the above-mentioned economic benefits that result directly from the reduced ACD, smelters which use anode slot cutting machines confirm that the slots also confer the following operational improvements: a) greater pot stability, b) improved current efficiency, c) better alumina dissolution, d) anode effects are reduced (almost eliminated), which results in:

- improved manpower productivity since anode effect frequency is reduced to a large extent
- safety and health hazards are eliminated owing to the lower anode effect frequency, and with immediate auto-quenching methods the operators are less exposed to hot pot conditions
- the emission of greenhouse gases (CO_2) is reduced.

Once an investment has been decided on and approved, the lead time before it begins operating is always critical. This has been carefully taken into account at T.T. Tomorrow Technology, where the standard procedure is as follows:

The automatic slot-cutting machine is fully preassembled in the company's own workshop and then fully tested in operation using anodes supplied by the customer, in order to carry out operational fine tuning. The machine is accepted by the customer at the T.T. workshop before delivery. This procedure reduces the time required for installation, commissioning and start-up on site, and the related costs, and therefore ensures trouble-free and fast delivery, commissioning and production start-up. The equipment is only prepared for shipment and delivery to the customer once it has been successfully tested and accepted at T.T.

In this way interruptions of on-going smelter operations are reduced to the minimum, as also is the impact on the anode production and rodding shops. Accordingly, the lead time before the new investment begins generating economic returns is as short as possible.

In conclusion: with short RoI times, even in the case of smelters having smaller production capacities, the implementation of anode slotting technology minimizes production costs and also pays due regard to the conservation of energy resources and thus to reducing environmental impact.

T.T. Tomorrow will be exhibiting at ALUMINIUM 2016, 10E27