Low Energy Start-up for Low Energy Cells

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Abstract

Along with the development of low energy cells, Hydro developed a range of operating strategies for low energy cell operation. Amongst these, a method for starting-up cells using as little energy as possible, along with eliminating anode effect-producing PFC emissions was developed. This paper presents the results and benefits of such procedures, that cover protection of the cathode surface, reduced energy during preheating and early life and emissions elimination during start-up.

Keywords: Low energy start-up of aluminium electrolysis cells; preheating of cells; preparation of cell preheat.

1 Hydro Aluminium Vision and Challenges about Low Energy Operation

Over the last few years, Hydro has started publishing on the results of its efforts in developing low energy electrolytic aluminium cell technology aimed both at retrofitting in its smelters as well as equipping its upcoming brownfield expansion in Karmøy [1 - 4]. It is the company's vision to be a leader in low energy, low emission aluminium production technology as part of its Bigger, Better, Greener approach. The long-term objectives include the development of affordable reduction cell technology that approaches an energy consumption of 10 kWh per kg aluminium, and achieve a company-wide neutral carbon footprint by the year 2020.

The contribution of Hydro's Primary Metal Technology team touches many aspects related to these goals. On the electrolytic cell technology development front, efforts focus on developing low-emission, low-energy cell technology compatible with heat recovery and carbon capture. The low-energy cell technology development team has made steps in designing cells able to sustain such demanding operation. The advances achieved in reducing electrical resistivity in all conducting elements of the electrolytic cells, the reduction of heat loss of the same cells, together with design optimization of the potshells and superstructure result in technologies having significantly increased capabilities. While these new cells remain fully able to operate in more "traditional" mode, e.g. at common voltage and amperage, they have the capacity of being run at much lower energy consumption.

This capacity is however not sufficient to guarantee stable low-energy operation in the long term. Indeed, sustained low energy operation requires changes in the process control strategy. The low heat loss of such cells makes them more sensitive to thermal deviations caused by common issues encountered during operation. The low-energy operating mode is implemented by using parameter sets and control code that reduce heat input and ACD variations. For example, low energy operation involves running the cells at reduced superheat compared with traditional operation. The low superheat in turn demands that adapted operating parameters for heat balance, alumina feeding and event handling be modified to ensure that a sludge-free and low anode effect frequency operation is maintained.

One critical element needed to sustain low-energy operation is to ensure that the linings exit unscathed from start-up and early life. Indeed, autopsies have shown that cells sometimes have bath or metal infiltrations that can cause rapid lining damage, making operation at low energy impossible and also significantly shortening potlife. Live measurements show that such infiltrations tend to happen early in the life of the cells, often within the first few days of operation. Careful analysis of the events happening during this critical period has led to modifications of the start-up and early life targets and procedures that decrease the risk of damaging infiltrations. Another target of this work is to reduce the time and energy required to start the cells; luckily, this objective is very compatible with the lining protection target mentioned above, so no compromises had to be done.

2 Traditional Cell Start-up Strategies

Although it is usually a single and relatively short event in a cell’s life, start-up is one of the most critical part of it. Indeed, bringing a cold, empty, freshly lined cell to a hot, liquid-filled and aluminium-producing state without causing damage or infiltrations is not straightforward. A complex, interlinked array of thermal expansion, shrinkage, sodium-driven expansion and deformations affect the various parts of the cell assembly during the various phases of preheating, start-up and early life. Moreover, these interactions are dynamic and do not happen simultaneously all over the cells: some areas like the corners tend to evolve slower than others, further increasing the complexity of the process. The sensitivity of a cell to damages further increases when it is larger and lightweight like Hydro’s newest cell technology.

The activities leading to a normally operating cell can be divided into five stages:

- Cell lining: where the potshell is lined according to specifications,
- Cell preparation: where the lined cell is equipped with anodes and insulation in order to be preheated,
- Cell preheating: where the prepared cell is heated to a desired temperature,
- Cell start-up: where liquid bath is poured into the preheated cell and anodes lifted to start the electrolytic process,
- Early life: where the operating parameters reach specified targets that aim at establishing long term, stable operation.

There are multiple variations on each of these stages in the industry. Every smelter has its own recipe, targets and limitations (in-situ lining, gas preheating or fast turnaround for example) that lead to compromises in the way every stage is performed. A wide range of procedures are therefore used, leading to significant variations in preheating quality, heating rates and chemical conditions during early life. These variations are most often not or only partially measured so that they are either accepted or simply ignored. These compromises often lead to similar results: bath is poured onto insufficiently or unevenly preheated cathode, then freezes over large areas of the cathode, leaving only a small area for the current to flow. This results in a high voltage developing in the cell (the “start-up anode effect”), with the typical voltage reduction following as the frozen bath melts and more cathode surface becomes available to carry current.

Figure 1 presents the voltage evolution typical of a traditional preheat and start-up. One can appreciate the start-up anode effect (followed by a genuine one shortly afterwards) and slow

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