Comparison of Pilot Anode Production and Testing Between Two Laboratories and Ability to Simulate Full Scale Anodes

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Abstract
Simulating industrial quality anodes at pilot scale is challenging. In the current study, Hydro Aluminium and RAIN Carbon prepared multiple sets of identical aggregate recipes and made pilot anodes in two different laboratories. Hydro Aluminium Technology operates two pilot lines at their Årdal facility in Norway and RAIN Carbon operates a pilot line at their Castrop-Rauxel facility in Germany. Pilot anodes 4-6 kg in weight were produced using two different coke blends at several levels of pilot anode settings. RAIN Carbon supplied 24 sets of a baseline aggregate using an industrial coke blend and crushed baked anode scrap. Hydro Aluminium supplied 32 sets of coke and butts fractions from a full-scale anode plant. Excerpts of the results are presented and compared for the green anode production and baking processes and general anode core analysis results. The use of pilot anode testing for simulation of full scale anodes is discussed.

Keywords: Anode Plant, Pilot Scale Testing, Comparative Study, Anode Production, Anode Analysis.

1. Introduction

Hydro Aluminium and RAIN Carbon (hereafter Hydro and RAIN) have a long history of cooperation, from general customer support by RAIN to scientific studies and co-authorship of research papers. Hydro is an integrated aluminium producer with extensive research activities including research on carbon raw materials for anodes. RAIN is a raw materials supplier to several industries including aluminium production where the main materials are petroleum coke and coal tar pitch. Both companies operate pilot scale anode testing facilities. Since 2015, a technical cooperation has developed with the intent of working jointly on comparative studies of raw materials. Hydro operates two pilot lines at the Primary Metal Technology (PMT) facility in Årdal, Norway. [1] RAIN operates a pilot line at their Castrop-Rauxel facility in Germany [2]. There are not many pilot anode testing facilities, and every line probably has unique features. Conducting parallel studies and sharing results between different pilot lines presents an excellent learning and benchmarking opportunity. This paper will describe the results of such a study between Hydro and RAIN.

1.1. Full Scale or Pilot Scale?

Testing of cokes and binders in a full-scale anode plant is feasible and will give the most realistic industrial results. However, continuous stable operation of an anode plant will always take priority over any form of testing. On this basis, testing at a pilot-scale facility is preferable. Other significant advantages of pilot-scale are lower cost, shorter testing feedback and far greater versatility in experimental designs.

1.2. Comparative Pilot Anode Studies

A first study was run to establish a methodology for sharing material sets, and to see the effect of parallel production at the two facilities with the same calcined petroleum coke (CPC) aggregate and binder. This data set is hereafter termed "Set1" anodes. The Set1 study was also used to compare analysis results. A smaller, second study was run where a different aggregate and binder was shared and used (Set2).

The Set1 aggregate was prepared by RAIN and the Set2 aggregate by Hydro using similar procedures. Two different binders produced by RAIN were used in the studies.

Table 1. Raw materials Set1 and Set2 tested at each site. Production temperatures (Tmix) were adapted to match the binder softening point. Tmix was the green mixing target.

	Anodes	Aggregate	Binder	Tmix [°C]	Binder Levels [wt%]
Set1	8	RAIN Baseline Coke	BX112M	180	13.5, 14.0, 14.5, 15.0
Set2	3	Hydro Paste Plant Fractions	BX125M	195	13.5, 14.0, 14.5

1.3. Requirements for Good Comparison

Several steps are critical for a successful comparative test of pilot scale anodes.

Equal Aggregate: Preparation of raw materials to ensure an identical set of aggregates was achieved by splitting to exact portions ready for adding to the mixer, for each fraction for both Set1 and Set2 aggregates.
Pilot Production: Understanding which settings in production must be the same at the sites - the anodes were produced under regular pilot production conditions at each site, except temperatures for preheat, mixing and forming which were adapted to the level suitable for the binders used.
Analysis Round Robin (RR): Participants must have confidence that anode test methods and results are comparable at both laboratories since the analysis results determines our understanding of the anode quality. An analysis RR was integrated in the first pilot anode study. At each site, a pair of anodes were made for every setting, and after baking, one anode from each setting pair was sent to the other laboratory for coring and analysis. When showing charts, this makes four points of results that should be as close as possible.

2. Experimental

2.1. Comparing the Two Pilot Scale Lines

An overview of the two lines is shown in Table 2. The Hydro pilot line in Årdal has been in operation with a vacuum vibroformer since 2005 with over 1600 pilot anodes produced. RAIN's relatively new pilot anode facility has been in operation in its current form since 2013 with just over 800 anodes produced. All of RAIN's aggregate preparation work is done at the RAIN central lab in Lake Charles, USA.

higher levels. These observations agree with literature on pilot anode production using a hydraulic press. [4]

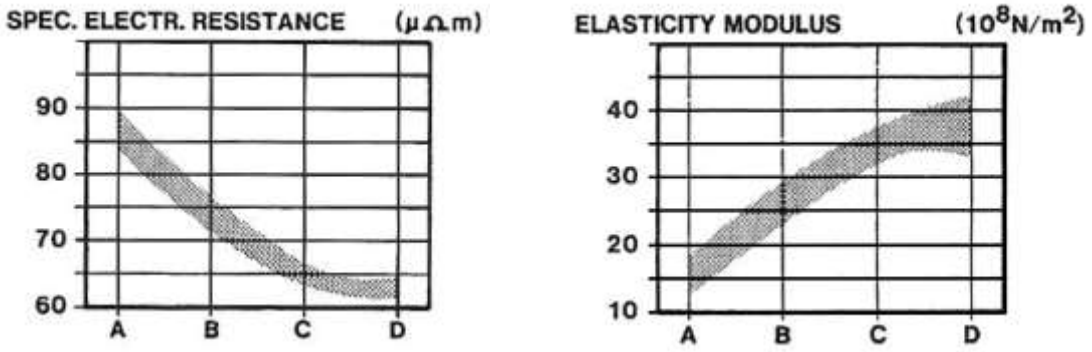

Figure 10. From reference [4], expected trend of Specific Electrical Resistance (SER) and Young's Modulus (YM) with binder level in anodes formed using a hydraulic press.

6. Conclusions

Both pilot anode lines investigated in this study have proven to show repeatable trending within the industrial range. Based on this, both pilot anode facilities are suitable for raw material testing and process optimization studies as an alternative to more costly, and time consuming, industrial trials.

Both pilot anode lines showed significant crushing of the coke aggregate during paste mixing despite different rotor configurations. The push-down method used in the Hydro lab is believed to result in higher compressive shear forces and generation of finer grains. It is not clear how much this influences final anode properties, but the extent of coke attrition is similar to that found in trials with large industrial mixers including co-kneaders.

Operated production equipment and development of operational practices result in good repeatability and meaningful trending at both sites being part of this study.

The analysis round robin indicated some minor issues with the reproducibility of some analysis results, and this will be investigated in more detailed future work.

So far, two comparative studies have been run as part of the technical cooperation between RAIN and Hydro, and exchange of results and discussions have been useful for both parties involved. Similar studies of new material will be arranged.

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