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ARTS - ANODE & ROD TRACKING SYSTEM – A NEW TOOL FOR OPTIMIZATION OF ANODE PERFORMANCE

Aluminij d.d.[1], Ivan Grle[1], Alfred Harwardt[2], Manfred Beilstein[2]
[1]Aluminij d.d., 25 Studeni bb, 88000 Mostar, Bosnia & Herzegovina
[2] Outotec GmbH, Albin-Koebis-Str. 8, 51147 Cologne, Germany

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Abstract

ARTS is a combination of an Anode and Anode Rod identification and Tracking System, including a customized database and analytical software.

ARTS effectively tracks both, anodes and rods, helping to control the quality of anodes and improve the overall smelter performance and rodshop operations and efficiency.

The system has recently been installed and is now successfully in operation at ALUMINIJ d.d. in Mostar, Bosnia & Herzegowina (hereinafter shown as AM).

The system provides permanent identification of rods and identification of anode blocks, thus enabling the control of anode performance in the smelter and rodding shop operations. Through the analysis of anode data recorded by the system and action taken based on this, improved anode quality and efficiency of operations can be achieved.

In this paper, the functionality and the key elements of ARTS are described, and an overview of the installation of the system at AM is provided, along with operational results.

Introduction

The consumption of carbon anodes represents a major cost and process influential factor in primary aluminium production. Therefore, one prerequisite to efficient smelter operation is the supply of anodes of consistent and high quality. In the past, numerous attempts have been made to automatically follow up anode production and performance in aluminium smelters by tracking of anodes and rod assemblies throughout the process of production and anode consumption. Systems explored did either not offer comprehensive functionality or were lacking features that have now been successfully implemented in ARTS™

Development and Field Trials

Since there were no proven solutions for the entire functional chain available on the market, Outotec decided to explore the requirements and functional steps, piece by piece, all based on established and proven technology and making use of readily available components and modules.

The system was developed and improved at Outotec as a R&D-project over several years. This encompassed component selection, short-term and long-term field trials in operating smelters and experimental set-ups in industrial environment. Finally, a prototype of the major system elements was constructed at ALUMINIJ d.d. Mostar (AM)., BiH

The key to the final success was to select and combine the following suitable methods and components to ensure that desired targets were met:

- Permanent & reliable identification
- Easy retrofitting
- No adverse effects to process and operations
- Cost-efficiency
- Easy maintenance & trouble shooting
- Clear structure of data tables

<u>Anode Rod Identification</u>

The system development started off with the part of the anode rod identification so that it is reliably machine-readable. The use of bar code or data-matrix identification is a known technique for this purpose (1). However, such elements had proven vulnerable in the environment and would as well require replacement every time the information content on it changes. OCR–coding (*Optical Character Recognition)* was also surveyed but dropped due to unsatisfactory overall performance. Therefore, the application of RFID-tags (*Radio-Frequency Identification*) was explored and finally chosen (2). These are low unit cost items, relatively easy to install and enable the writing and reading of information (Figures 1 to 3). What had yet to be tried out was the use of such tags in the harsh environment with high temperatures, extraordinary magnetic fields, dusty atmosphere and tough mechanical handling.

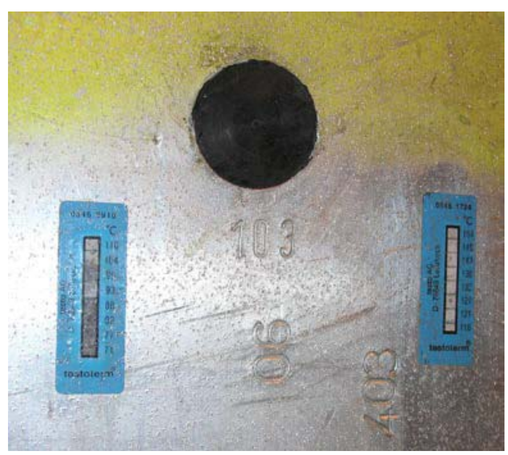

Figure 1:RFID-tag on anode rod and temperature monitoring strips at early field trials

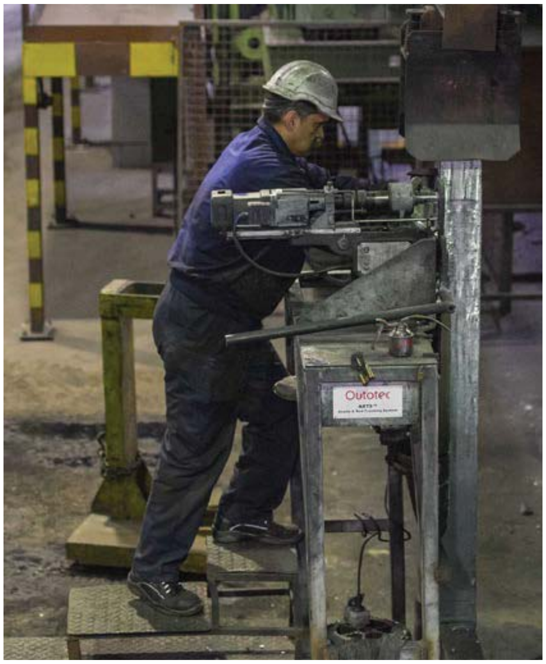

Figure 2: Drill Kit, installed on a platform under the overhead conveyor by-pass loop, for drilling the recess for the RFID tag into the anode rod at AM.

Figure 3: RFID-tag installed in aluminium anode rod (retrofit) just below bell, in its final shape.

As a conclusion from field trials, the method chosen was:

- to embed the RFID-tag into the anode rod, in order to maintain the flush rod surface and avoid damage to the tag by the rough handling of the rod in the potrooms and rodding shop.
- to provide a protective cover to the tag to avoid direct exposure to the operating environment with mechanical impact, abrasives, heat and dust.
- to apply an easy, reliable and low cost method to retrofit the tags to the rod assemblies of an operating smelter

<u>Rod Reading stations</u>

Reading the RFID tags of the anode rods is done by antennas connected to a reading device installed in the field (Figure 4). The equipment chosen withstands the harsh environment of the Rodshop and allows reading "on the fly", the moderate speed of the overhead conveyors does not necessitate a complex set-up.

As the orientation of symmetrical rod assemblies in the conveyor is random, two antennas were installed at each station to allow recognition regardless of the tag passing by near- or off-side. At these stations, information may also be written (or erased) to the RW type tags.

The number and location of the reading stations depends on the functionality envisaged with the system, as well as on the rodshop layout and arrangement of the machinery.

Figure 4: Reading station for rods

<u>Anode Block Identification</u>

The task of marking and tracking of the carbon anode block from the molding machine (vibrocompactor), through anode baking and up to the rodding of the baked anode block to the rod assembly in the rodding shop was conceptualized and developed.

The reading of numerical characters (OCR), like imprinted digits, which are used in the industry for automatic marking of green anodes for many years, proved to be not fully reliable when a visualisation system was used for the recognition purpose (camera & special object lighting). Residues of packing coke from the baking furnace were the major obstacle experienced at this point. Consequently, a more robust marking method, less sensitive to such disturbances, in the form of a dot-code imprint was developed and refined (Figure 5).

This imprint method had to be designed for:

- application in the immediate vincinity of the vibrocompactor on freshly molded, hot anodes, strictly avoiding any damage to the anode surface or structure.
- giving a good imprint, to survive the anode baking and baked anode cleaning.

- assuring a reliable recognition of imprint after baking & cleaning, tolerating packing material residue to a remarkable extent.

Initial field trials with imprint mechanisms for manual imprinting provided the basic criteria for dot size and shape, dot spacing and number, as well as the required force for imprinting.

All this led to the design of an automatic dot-matrix printer, which has been successfully in use at AM since April 2012. It was installed to replace the existing anode marking device with digits.

Figure 5: Dot Code Stamping unit at AM

Thus, each anode molded at the vibrocompactor is imprinted with a unique dot-code for this particular anode block, and the system automatically correlates the green anode production data to this code number, including the output data of the vibrocompactor control system (such as: dot-code, date and time of forming, vibrating duration, anode weight, anode height, calculated green apparent density,) and any other available production data of the paste plant operation, such as pitch content, mixer power, dry aggregate recipe, type of carbon raw materials, etc.

Anode reading stations

An anode reading station installed at the FTA (Furnace Tending Assembly) anode pick-up point provides the FTA control system with the anode ID. This allows the correlation of the baking furnace process data to the particular anodes, such as section and pit number, pit position, fire advance cycle, soaking temperature, etc.

This installation is presently engineered and to be added to the system at AM at the next opportunity.
The baked anode then is conveyed to the baked anode storage, from there it is transferred to rodding station when it is necessary.

The rodding station is the key installation of the system, as the access to the anode data is via the rod ID from here on up to stripping off of the spent anode; the dot-coding is surrendered as it is no longer required after the combination of anode and anode rod.

Fig. 6 shows the installation with the camera and special light source, which makes the unit insensitive to daylight, artificial plant lighting and flashing from the casting process.

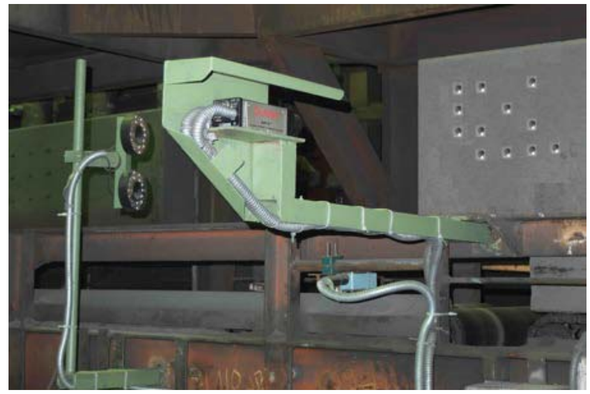

Figure 6: Camera & IR light source at rodding station, capturing the baked anode

The rodded anode is transferred to the potrooms. Reading stations (of the rod tag) at the PTM (Pot Tending Machines) allow access to the data needed for setting the assemblies at the desired height into the pots and to register the pot number and place in pot where the anode is placed. Customer specific data acquisition of the electrolysis process adds valuable information to the database. Analytical software accessing all the available data help improve efficiency and process optimization.

Rod and Stub Repair

A significant cost in the operation of the rodding shop is the repair of damaged stubs and rods. Due to the nature of the process such damage cannot be avoided, and repairs become necessary at intervals.

Since the number of rod assemblies in use in big smelters goes into tens of thousands, it is of essence to the smelter operator to keep track of the condition of rod assemblies in use, since a substandard condition inevitably will result in drop of efficiency and some production loss.

The ARTS system enables tracking of the condition and quality of the total population of anode rod assemblies, with the life-cycle history of each rod assembly being stored on its RFID-tag.

Application of the ARTS system at Aluminij d.d. –Mostar

Fitting of RFID Tags at the Anode Rods

A drilling and tag fitting station was installed on a mobile platform, the fitting of tags was performed by shift personnel and took only a few month to fit the approx. 7,000 rods with tags. (Figures 2 and 3)

Anode rod reading stations

These were installed at the arrival of spent anodes in the rodshop, at the weighing stations to determine the bath material and butts masses, the cleaning and inspection stations, the straightening and repair stations for rods and yokes, and finally the rodding station receiving a fresh anode.

A typical reading station is shown at Fig. 4.

<u>Anode Dot Code Stamping</u>

A dot code stamping device was installed at the vibrocmpactor (Figures 5 and 7) the control software was amended to the vibrocompactor

Figure 7: Anode push-off at vibrocompactor

<u>Camera station at Rodding Station</u>

A vision camera reading the dot –code of the anodes was installed at the rodding station. It is synchronized with the rod tag reader and delivers the unified information to the database.

<u>Control Cabinet, Operator Station and Database</u>

These are installed in the rodshop control room to give the operators immediate access to the system. A second operator station is installed in the plant engineering office; from there all analytical and statistical tasks are performed (Figures 8 – 10)

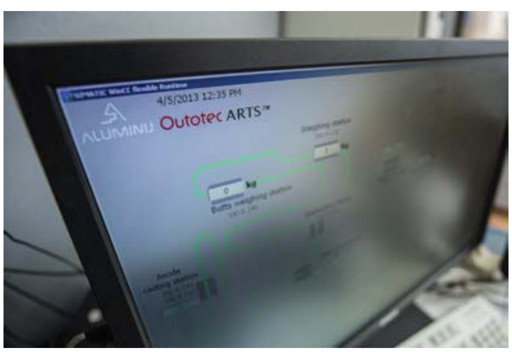

Figure 8: Operator station for ARTS

<u>Future steps</u>

The next step to follow will be linking ARTS to the PTM's, to add the position of the anode in the pot to the system data base. For this task a rod reading device will be installed at the PTM and an indexing device added to the operator's cabin.

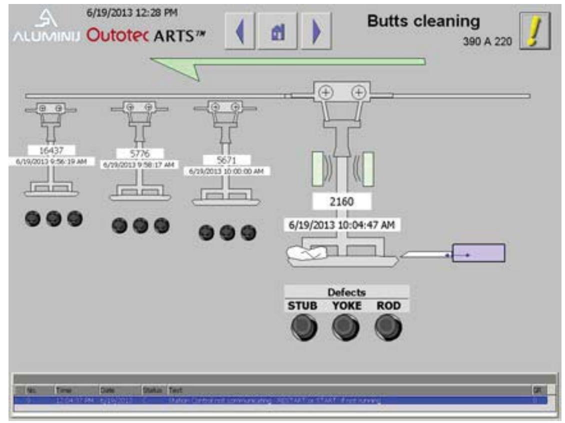

Figure 9: SCADA screen with ARTS "Butts Cleaning" – station

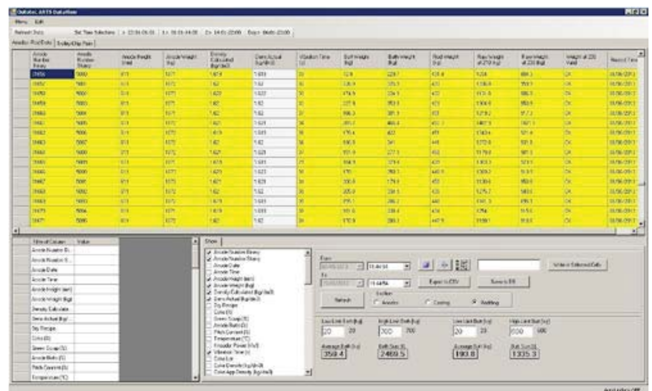

Figure 10: Excerpt of ARTS data-table with anode and rodding data

<u>ARTS has become an adopted measure to improve operations and production at Aluminij d.d. Mostar</u>

Aluminij's operation and process teams have started to implement ARTS into their plant monitoring and improvement routines.

For the green anode production this includes paying special attention to raw material properties, paste recipes, paste production and anode forming data.

Another important issue is to monitor the cast iron composition as a parameter for reducing the voltage drop at the electrolysis process.

ARTS also provides them valuable information as to the anode consumption data per ton of Aluminum produced, and, monitoring abnormal values, helps to timely detect problems either within the electrolysis process or with anode parameters.

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