# From 110 to 175 kA: Retrofit of VAW Rheinwerk
## Part II: Construction & Operation

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### Abstract

Construction, start-up and operation of ten retrofitted 165 $kA$ prebaked pilot cells in the Rheinwerk Smelter is described. The excellent performance of these pots led to a DEM 40 Million investment decision to retrofit all potlines. The hot-change of cells during full potline operation minimizes production losses.

The pilot cells are equipped with improved steel shells and potlining, modified busbar system and modern pot controller as well as point-feeder and alumina conveying system. To evaluate the most cost-effective solution with best performance four cells are provided with two point-feeders and six cells with three point feeders. The new-developed VAW-*ELAS* process control system with improved control algorithms and a user-friendly graphical interface allows systematic surveillance and interpretation of all pot parameters and has a major contribution to the highly improved pot performance.


### Introduction

The Rheinwerk Smelter of VAW aluminium AG is located in Neuss, some 15 km away from Dusseldorf. This smelter went on stream in 1962 with a first construction stage comprising 162 pots in three potrooms. The original VAW developed pots were based on the so-called *Erftwerk* design with pre-baked continuous anodes operating at 110 $kA$. The pots were charged with pneumatic crust breakers. Typical operational results at that time were 86 % current efficiency, the specific energy consumption was as high as 16.2 $kWh/kg\ Al$. The rated capacity of the smelter was 45,000 tpy. A plant photo of this first construction stage is given in *Fig. 1*.

During the years 1970-1973 potline 2 and 3 were commissioned with each 156 cells arranged in six potrooms. The same basic technology as installed in the first construction phase was used, yet the amperage was increased to 126 $kA$. In contrast to the first system the *Erftwerk* cells were individually hooded as shown in *Fig. 2*. For waste gas cleaning four twin fluidized bed scrubber were installed. The total capacity of Rheinwerk Works at that time increased to 145,000 tpy.

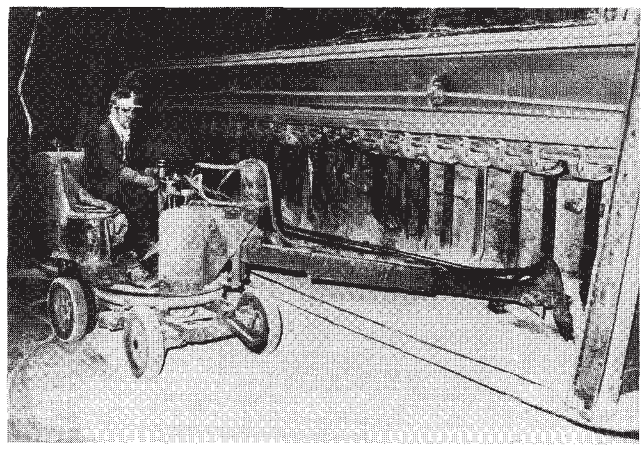

Figure 1: Rheinwerk Smelter 1965 with first generation *Erftwerk* pots

During the years 1981-1984 the smelter was modernized to secure the long term future of the plant by installing a more environmental acceptable, ergonomic and energy-saving technology. The *Erftwerk* anodes were replaced by discontinuous prebaked anodes. Whilst the cathodes of the pots were kept in operation the pots with the new designed superstructure were completely hooded and centre-breaked.

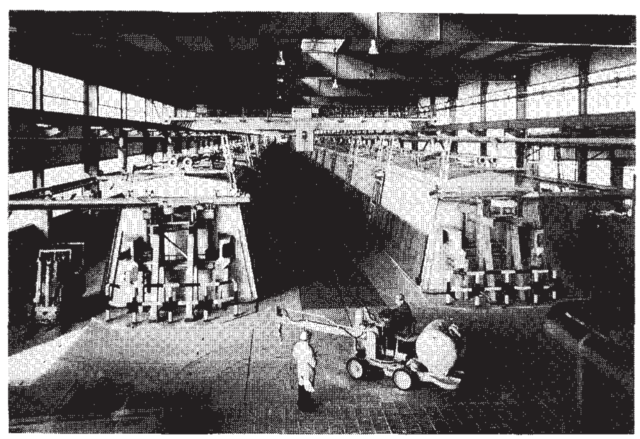

Figure 2: Hooded *Erftwerk* pots, 1975

A microprocessor based pot control system was installed. Due to the larger anode table of the discontinuous anodes the amperage could be boosted to 165 $kA$. The rated capacity of the Rheinwerk Smelter thus increased to 210,000 tpy.

In the early 90's VAW Aluminium-Technologie GmbH, a 100-% subsidiary of VAW aluminum AG, was asked to develop a retrofit concept for the Rheinwerk Works to increase productivity and operational results of the smelter. The outcome of this project was a modernization package including the following measures:

- Modification of busbar system
- New pot shell and potlining
- Point feeder and alumina conveying system
- Newest generation of VAW-*ELAS* pot control system.

According to computer based simulation tools an increase in amperage up to 175 $kA$ will be possible, c.f. VOGELSANG et al. [1]. Ten pots were modernized according to this concept in a potroom temporarily closed during the recession of the aluminium market. These cells were commissioned in 1995 with a current load of 165 $kA$. The promising operational results after one year of operation led to the decision to retrofit all the three systems with capital expenditures of DEM 40 Million. The current load of the systems will be increased in 1996.

## Modification of Busbar System

The original busbar system was symmetric in design with four risers and two cathodic busbars at each side picking up 1/3 and 2/3 of the collector bars. Based on magneto-hydrodynamic simulation the retrofit concept foresees a three-riser configuration that compensates the magnetic influence of the adjacent potline. One downstream riser opposite to the adjacent potline was to be cut-off and the two cathodic busbars on that side had to be connected. For the first pots a rather intricate welding joint was accomplished. During the welding process the pots had to be taken out of operation. Plant trials indicated that a bolted clamp connection of the two busbars had no discernible increase in voltage drop compared with the welded joint. The cost of the busbar modification for this clamped connection reduced to DEM 900 per pot compared with DEM 4,500 for the welded joint. In addition the pots could be kept in operation during the busbar modification. Meanwhile the busbar systems of nearly all the three systems are converted. For pots with this modified busbar system cell stability was amazingly improved and metal pad rolling was not observed any more.

## Cell Construction

Ten pilot cells were taken into operation to demonstrate the potential of the retrofit measures. Seven of these demonstration pots are equipped with a new cradle steel shell, new flexibles and an improved potlining. Three pots still operate with the cathode design of the former pot generation. Some basic data for the newest pot generation are given in [1]. In an attempt to evaluate the most cost-effective modernization concept four cells were equipped with two point feeder and the remaining six cells with three feeders, c.f. *Table 1.*

Table 1: Superstructure of the demonstration cells

| | **2-Feeder** | **3-Feeder** |
|---|---|---|
| Crust breaker/Feeder | 2 | 3 |
| Alumina hoppers | 2 | 3 |
| Bath material hoppers | 1 | 1 |

During the reconstruction a prefabricated superstructure with integrated point feeder and hoppers replaces the existing superstructure with alumina hopper and a long crust breaker while the pots are still in operation. A schematical drawing of the three-feeder version of the superstructure is given in *Fig. 3.*

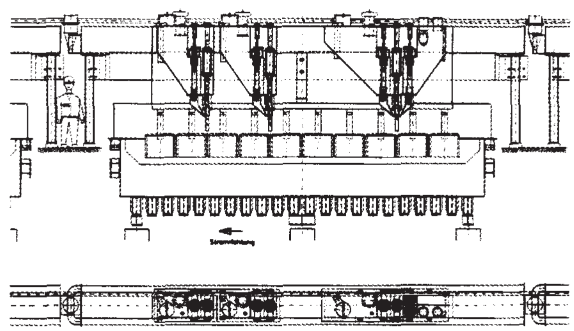

Figure 3: Superstructure with three point feeder

During the evaluation period of one year no discernible difference in operational results were observed between these two versions of the demonstration pots. The modernization of the remaining pots in the three systems will therefore be accomplished with two point feeder per pot. A plant photo of the demonstration cells is given in *Fig. 4.*

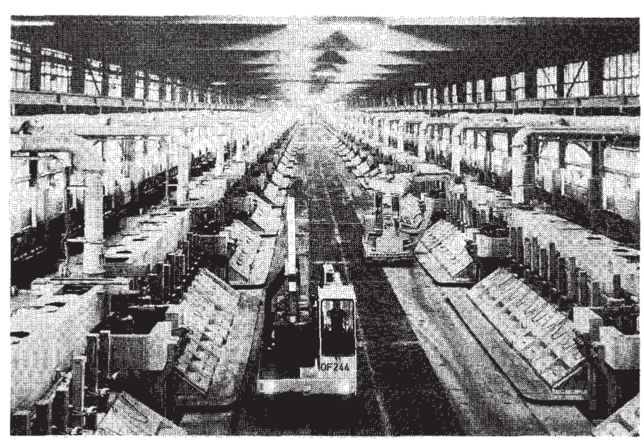

Figure 4: Demonstration pots at Rheinwerk Smelter

For the demonstration cells the newest generation of the *ELAS* pot control system was installed in the existing control cabinets serving each two pots at the same time. This new pot control system together with the busbar modification and the new pot shell and potlining contributes to the strongly improved operational results of the demonstration pots. This pot control system is based on a decentralized design with a process control layer and a supervisory layer. The layers are linked via an *Ethernet* network that handles the information exchange for process data, parameters and complete control code for the controllers. The high-sophisticated control algorithm is based on a resistance-dependent alumina feeding control of the point feeder and automatic a.c.d. control to achieve the best possible current efficiency and energy consumption. The supervisory level is designed with on client-server model with a graphical user interface (*X11/Motif*) presenting status information as charts, tables, report as well as alarm handling system. The scheduled anode effect frequency is as low as 0.2-0.3 per pot and day. Examples of process diagrams produced by the *ELAS* system are given in *Fig. 5* for a pot during an anode change.

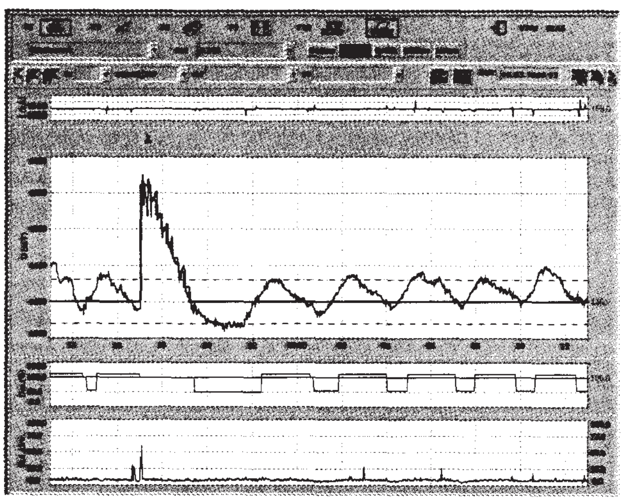

Figure 5: Process control chart during an anode change

## Start-up and Operation

Commissioning of the demonstration pots took place from April to June 1995. For preheating mixture of graphite and petroleum coke with defined grain size as a resistor was placed between anodes and cathodes. The cathodes were electrically preheated in a conventional way monitoring the cathode surface temperatures carefully. Some data of the start-up process are given in *Table 2.*

During the construction period there was some concern regarding the performance of the two-feeder pots as far as reliability for extinguishing anode effects as well as the rate of alumina solubility are concerned. Typical anode effect diagrams as monitored by the *ELAS* pot control system demonstrated that there is no difference in the time needed for extinguishing the anode effect for both cell versions. The success rate of automatic anode effect extinguishing is better than 98 % and the time needed for this action is as short as 2.0-2.5 *min*.

Table 2: Start-up phase

| | |
|---|---|
| Pre-heating time | 72 *h* |
| Energy consumption | 30,000 *kWh/pot* |
| Surface temperature cathodes | 900°*C* |
| Bath introduced during start-up | 8,000 *kg/pot* |
| Duration of 1st anode effect | 40 *min* |
| Voltage during anode effect | 35 *V* |
| Metal added after | 24 *h* |
| Amount of metal added | 8,500 *kg* |
| Metal height | 18 *cm* |
| Bath level | 18 ± 2 *cm* |
| Start of demand feed control | 6th day after start-up |

Operational results after one year of operation as given in *Table 3* for the demonstration pots with two and three point feeder together with data for the rest of the three systems of Rheinwerk Works indicate no discernible difference, too.

Table 3: Operational results

| Cells | Voltage [*V*] | Current efficiency [%] | Spec. energy consumption [*kWh/kg Al*] |
|---|---|---|---|
| 3-points | 4.45 | 93.4 | 14.20 |
| 2-points | 4.45 | 93.5 | 14.18 |
| Average | 4.45 | 93.5 | 14.19 |
| Average of 3 systems | 4.68 | 92.0 | 15.19 |

The net anode consumption for the demonstration pots is 400 kg/t Al compared with 430 kg/t Al for all three systems. The anode effect frequency due to the new *ELAS* controller was as low as 0.3 */day · pot* instead of 1.2 */day · pot* for the rest of the system.

## Conclusions

Ten pilot cells were taken in operation at Rheinwerk Smelter to demonstrate the potential of the existing plant. The results after one year of operation can be summarized as follows:

- The busbar system was improved in a very efficient and inexpensive manner. Pot operation as far as magnetohydrodynamic stability is concerned was significantly improved.
- Installation of new developed pot shells and potlining as well as the newest generation of the *ELAS* pot control system resulted in a substantially improvement of pot performance compared to the existing cells.
- There was no difference between pots equipped with two and three point feeders as far as anode effect extinguishing time and operational results are concerned.

The improved operational results of the demonstration cells led to the decision to modernize all the three systems at Rheinwerk Plant with capital expenditures of DEM 40 Million. The estimated amortization period of this retrofit project will be four years.

## References

[1] D. Vogelsang, I. Eick, M. Segatz and Ch. Droste, *From 110 to 175 kA: Retrofit of VAW Rheinwerk. Part I: Modernization Concept*, Light Metals 1997 (to be published).