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VAW EXPERIENCE IN SMELTER MODERNIZATION

V. Sparwald, G. Wendt and G. Winkhaus

VAW Vereinigte Aluminium-Werke AG, D-5300 Bonn 1

In 1978, VAW initiated a smelter modernization program scheduled to be completed in 1984. This program comprises the replacement of 35 kA potlines by a 180 kA line in one smelter and the retrofit of 125 kA pots with amperage increase to 170 - 175 kA in a second plant, resulting in a capacity expansion from 180,000 to 265,000 annual metric tons all together. In the new systems centerworked prebake cells are installed. Due to different local conditions the pots are set side by side in the first smelter, and end by end in the second. The paper deals with experience in the execution of the program and with characteristic features of the new systems.

Introduction

Since the 1970's the primary aluminum industry in the Western World is faced with severe problems. As is well known, the major factors for the changed climate are energy and environmental standards. The forced obsolescence - as it was called at an AIME panel discussion, a few years ago - not only of old but also of relatively young smelters, due to the external changes, is threatening the very existence of plants.

One consequence of this development is the shift of new production capacities to places outside of the industrialized countries. However, since we strongly support the view that a significant portion of the metal consumed in our countries should be produced in domestic smelters for technical, economic, and political reasons, there is a challenge to our industry to adapt to the new conditions by modernization of smelters.

In the Federal Republic of Germany, at the end of the 1970's, of the 1.1 million annual tons*) of primary aluminum consumed, about 740,000 tons were produced in ten smelters, four of them built more than 40 years ago, the remainder being mostly less than 10 years old.

VAW's part of the smelting capacity in our country amounts to approx. 50 %. In 1978, VAW started a 6-year modernization program. The program includes replacement of 180,000 tons obsolete capacity by 265,000 tons of modern capacity in two smelters, the added capacity being reduced to about the previous level by shutting down and reducing, resp., the production in two other smelters of the older generation.

The updating of the two smelters was forced upon our company mainly by economic pressure in the case of the older South German Innwerk plant and by environmental reasons at the much younger Rheinwerk smelter.

The application of modern technology in the two plant brought about reduction of emission and low consumption figures, i.e. lower production costs. In order to be economically feasible, rebuilding and retrofitting had to be accompanied by an expansion of the production capacities of these plants.

Modern technology in this sense means computer-controlled centerworked prebake pots, high amperage, and dry gas scrubbing. Increase in ampere load and pot size is one of the most remarkable developments in smelting technology over the last five decades as shown in Fig. 1 for VAW smelters, a trend representative for the worldwide development. The main driving force of this development is the gain in production capacity per unit potroom area with increased amperage at nearly constant anode current density (Fig. 2); other factors being reduced labor costs and easier process automation.

The conditions for the modernization of the two plants differed widely, as discussed below.

Reconstruction of the VAW Innwerk Smelter

VAW's Innwerk smelter plant is situated in Bavaria, South Germany. The plant went into operation as early as 1924 with small 12 kA prebake cells and a capacity of 7,200 annual tons. The site was chosen because of the availability of hydroelectric power from the neighboring power station owned by an affiliated company, also because of a market outlet to the neighboring

*) Tons are metric tons

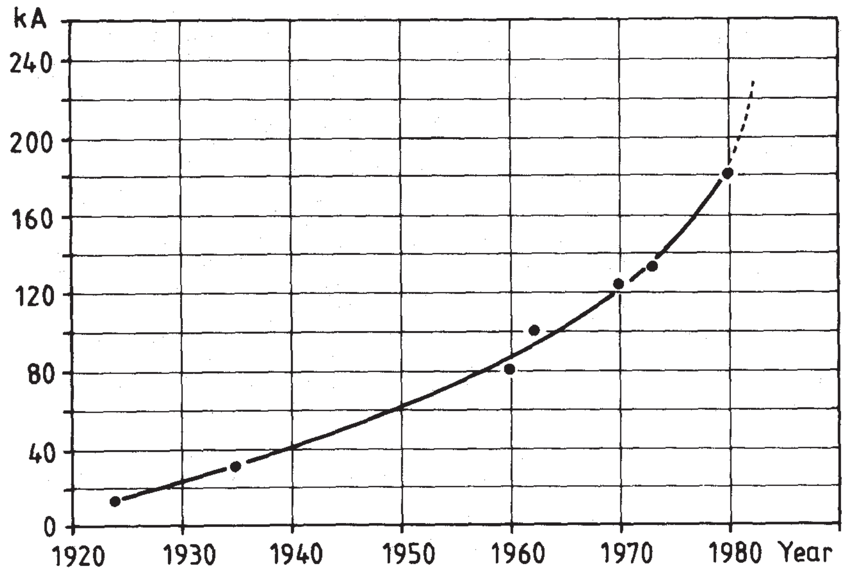

Fig. 1 - Amperage increase in aluminum smelting (VAW, new potlines)

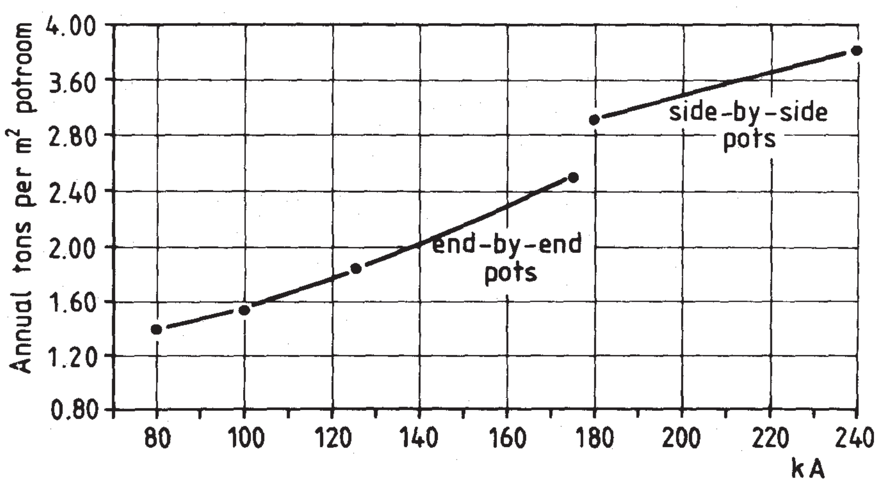

Fig. 2 - Production capacity per unit potroom area in dependance on amperage

South German manufacturers. Later on, the capacity of the smelter was expanded: 30 kA potlines, and finally, a 100 kA potline, were installed. Peak capacity was reached in 1970 with 70,000 annual tons which was reduced to 55,000 tons for economic reasons in 1972. During the last years the existence of the plant was increasingly threatened by the high costs due to high energy and manpower demand in operation of the small 30 kA pots.

The modernization program for the plant covered the 30 kA potlines, later operated at 35 kA, leaving the 100 kA potline with a capacity of 22,000 annual tons unchanged. Complete dismantling of the obsolete 30 kA prebakes together with pulling-down one potroom and construction of a new potroom, installation of new pots, erection of gas cleaning facilities and provision for a anode rodding shop were required. In addition, changes were necessary in the Innwerk casting house and in the carbon plant of our West German smelter supplying anodes to the Innwerk.

The reconstruction was carried out without interruption of production. Therefore and because part of the new potline is erected at the site of a pulled-down old potroom, the program was executed in two steps. The first stage of the new system went into operation with 86 pots in 1980, the second stage with 34 cells early in 1982. The capacity of the new potline amounts to 60,000 annual tons. The smelter has thus an overall capacity of 80,000 - 85,000 tons including 22,000 tons of the unchanged potline with 100 kA side-worked prebakes.

Some characteristic features of the new system may be described as follows:

Reduction Cells and Potrooms

The pots are of the now rather common centerworked prebake type. The option was for an amperage of 180 kA, anode current density 0.78 A/cm², and an appropriate cell size. 120 pots are installed side by side in two adjacent potrooms, each 416 m long and 22 m wide. Included are five experimental cells which may operate at 220 - 250 kA.

Current connection between the cells is effected by four risers. Disturbances in the metal pad by electromagnetic forces are effectively reduced by suitable arrangements of bus bars determined by computer-assisted evaluation of various models.

The two potrooms are served by three multipurpose cranes, prototypes of a system developed jointly by the Noell company (G.g. Noell GmbH, D-8700 Würzburg 1) and VAW. Provision is made for moving cranes from one potroom to the adjacent room. The cranes have integrated hoppers for alumina and solid bath constituents with four feeders for supplying these materials into the pot bins, an anode handling system, and a device for positioning and weighing the tapping crucible. They are operated from an air-conditioned cabin. After initial mechanical troubles have been overcome, the performance of the cranes is excellent.

In the new system, computerized process control is applied with microprocessors, one per cell, communicating with the main computer.

The feed system consists of a breaking beam with integrated point feeders. In normal operation alumina is fed through openings in the crust by the point feeders at short intervals. If required, e.g. during an anode effect, the beam can break the crust over the whole length of central spacing of the pot.

A general view of a potroom of the new line is shown in Fig. 3, a crane in operation in Fig. 4.

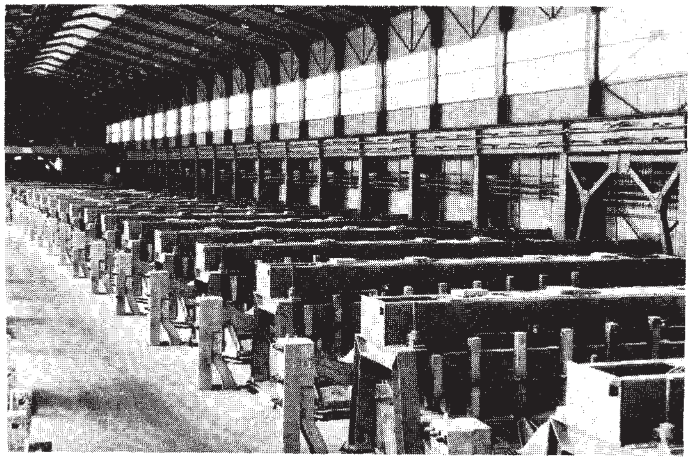

Fig. 3 - Potroom with 180 kA cells

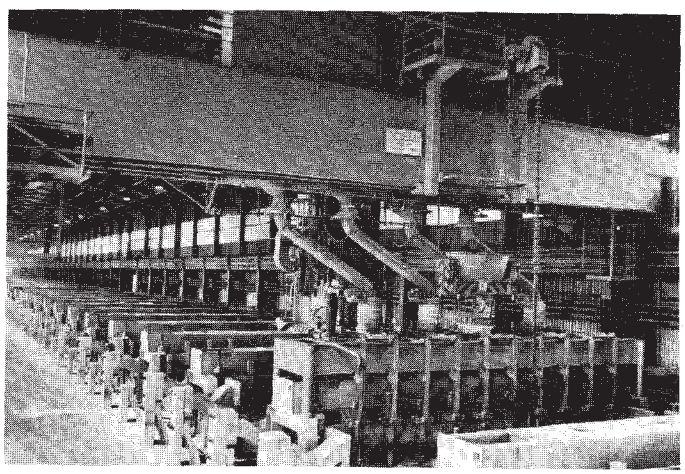

Fig. 4 - Multipurpose crane in operation

Bath Composition

Bath composition influences current efficiency and energy efficiency. Most modern smelters now are in favor of a rather high excess of AlF_3 over the cryolite ratio. This allows a lower working temperature of the bath and lowers the metal solubility in the bath, both factors being favorable to current efficiency. We are also using a low bath ratio but, in order to maintain a high electric conductivity of the melt, we add lithium salts in the new system. It has been found that the LiF-containing baths are less sensitive to changes in alumina quality. This is of interest to us because presently the Innwerk plant has to accept aluminas of differing quality. The lithium pickup by the metal does not cause problems because the Li content in the metal is easily reduced down to less than 1 ppm by treatment of the liquid metal with a gaseous mixture in the casting house.

Gas Cleaning

Pot gases collected from the hooded cells with a collection efficiency of approx. 97 % pass through a gas duct to the dry scrubbing unit. The scrubbing system applied in a production plant for the first time has been developed by VAW-Lurgi and has been described before (1,2). The principal flow sheet is shown in Fig. 5.

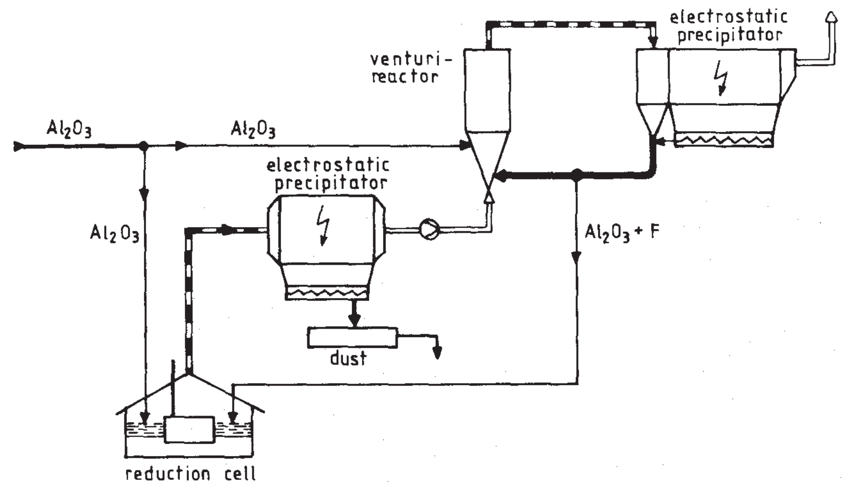

Fig. 5 - Flow sheet of the VAW/Lurgi dry gas scrubbing process

The pot gases dedusted in an electrostatic precipitator are delivered by a blower to a venturi reactor. There gaseous HF is adsorbed from the gas stream by fluidized alumina circulating between the venturi reactor and the subsequent second electrostatic precipitator. Part of the loaden alumina is taken out of the latter precipitator and delivered to a silo for use in electrolysis. Only 20 - 30 % of the alumina requirement of the electrochemical process is used for fluorine adsorption.

Clean gas concentrations of less than 1 mg F_{gas} per cu.m (NTP), corresponding to less than 0.1 kg F_{gas} per ton Al, and of less than 30 mg dust per cu.m (NTP) are obtained under operational conditions. Thus the legal standards are met.

One important advantage of this scrubbing system is the removal of 95 % of volatilized impurities together with the pot dust thus avoiding their recycling with the loaden alumina, harmful both to metal quality and current efficiency.

Two scrubbing units of this type (Fig. 6), each with a capacity of 300,000 cu.m (NTP) pot gas per hour are placed between the two potrooms of the new line.

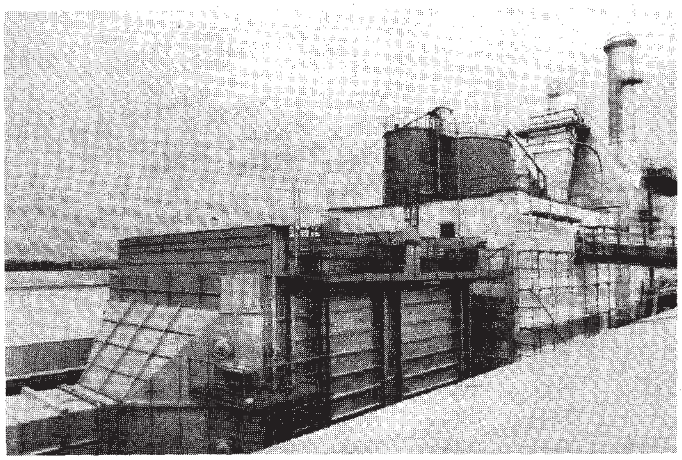

Fig. 6 - Dry gas cleaning unit at the VAW Innwerk smelter

Rodding Shop

The rodding shop was installed in one of the old potrooms. The overhead conveying system, constructed by the Westfalia Company (Gewerkschaft Eisenhütte Westfalia, D-4670 Luenen), works with electronically controlled automotive trolleys. The anode rods with adhering buts delivered from the potrooms move to the cleaning area where buts are stripped and rods and buts cleaned. The cleaned rods are conveyed to the assembly area where they are joined to the anode blocks by using molten cast iron. The investment costs of the system are much lower than for a power-and-free system and the maintenance demand is low.

Performance of the Potline

The new system is in smooth operation.

Energy consumption is less than 14 DC kWh/kg, current efficiency higher than 90 %. Man-power demand for electrolysis is approx. 2 hours per ton Al as compared to about 8 hours in operating the 30 kA pots.

Modernization of the VAW Rheinwerk Smelter

The Rheinwerk plant is situated near Düsseldorf on the bank of the Rhine river. Power is supplied to the smelter from thermal power stations based on lignite in the neighboring district.

The plant is comparatively young. It started production in 1962 with 110 kA sideworked cells with continuous prebaked anodes. Subsequently the capacity was expanded, and in 1980 the production capacity was 145,000 annual tons smelted in three potlines at an amperage of approx. 125 kA. In the case of this smelter modernization was necessary because of the stricter environmental regulations.

Structures of buildings and reduction cells being rather new, it was decided in this case to retrofit the existing potlines.

Buildings, bus bars, cell sheets, and cell foundations were used to substitute 145,000 tons capacity of the sideworked potlines by 205,000 tons capacity with centerworked pots.

This capacity rise has been made possible by rising the current load from approx. 125 kA to 170 - 175 kA.

Basically the same principal pot design was used as in the Innwerk smelter. This design had to put up with conditions which were more adverse than was the case of the Innwerk smelter reconstruction:

- The pots are arranged end by end,
- no head room was available for a multipurpose crane.

Consequently, no optimum compensation of magnetic fields was possible, and servicing of the pots has to be accomplished with floor vehicles.

This reconstruction necessitated also a new gas cleaning system. Also, a new rodding plant had to be built. The same type of equipment was used here as was in the meantime successfully tested at the Innwerk smelter. Changes had also to be made in the existing carbon plant.

All these measures were executed without interrupting the normal plant production. Two major difficulties had to be overcome:

- Two different current loads had to be used to operate one single potline,
- anodes of widely differing size had to be manufactured simultaneously in the same carbon plant.

The retrofitting in the Rheinwerk smelter started in 1982, is currently well under way and is expected to be terminated at the end of 1984.

Conclusion

Summarizing we can say:

By the measures described the objective, i.e. updating the smelters to present demands and increasing the productivity, has been fully attained.

In the case of the Innwerk smelter the total investment was 180 million DM. This sum was spent for an entirely new potline with gas cleaning facilities and for installation of a new rodding plant in an existing building. It also includes interest during construction period and costs ensuing from changes in auxiliary facilities like casting house and carbon plant. Related to the newly installed capacity of 60,000 annual tons the specific investment was 3,000 DM per annual ton. In comparison with the necessary capital outlay for a corresponding smelter capacity in a new location these figures appear justified.

In our view, the reconstruction of the VAW plants is a positive contribution to the objective to primary metal production in our country in the future.

References

1. E. Boehm, L. Reh, V. Sparwald and G. Winkhaus, "Removal of Impurities in Aluminum Smelter Dry Gas Cleaning using the VAW/Lurgi Process", AIME Annual Meeting, Las Vegas, 1976.

2. US 3,907,971, 1975, Metallgesellschaft and VAW;
   US 4,006,066, 1977, VAW and Metallgesellschaft.