



Tankhouse Optimization by METTOP GmbH

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Abstract

The secondary copper producer, Montanwerke Brixlegg AG (Austria), produces 73 000 tonnes of cathodic copper per year using ISA tankhouse technology. METTOP GmbH (Austria) evaluated the different anode qualities from the plant with relation to the current efficiency and specific energy consumption.

Parameters including the chemical and physical anode quality, current and current density distribution at each cathode, voltage, and distance between each cathode and anode were examined. In addition, the temperature, chemical analysis, and conductivity of the electrolyte was determined for each investigated cell, as well as the anode weight, anode scrap, cathode sheet, and short circuits. Metallographic analysis was also performed on selected dendrites.

The investigations resulted in specific improvements in the tankhouse process including the level of anode impurities, and future projects are planned for further tankhouse optimization.

Introduction

Montanwerke Brixlegg AG, Austria, produces 73 000 tonnes of cathodic copper a year using the ISA tankhouse technology. Due to the fact, that Montanwerke Brixlegg AG is a secondary copper smelter, the chemical analyses variation of the anodes is huge, compared to a primary smelter. Furthermore anodes from the secondary smelter Kovohuty, Krompachy, Slovakia, a subsidiary company of Montanwerke Brixlegg AG, are refined at the tankhouse in Brixlegg.



At the tankhouse of Brixlegg 16 groups with 13 cells are used. A cell contains 57 anodes and 56 cathodes. The anode crop takes fourteen days and the cathode crop seven days. The nominated current density is 320 A/m² and the average current efficiency is around 96 %.

METTOP Metallurgische Optimierungs GmbH, an Austrian engineering company providing metallurgical process improvements for the copper industry, was asked to evaluate the influence of different anode qualities in combination with the main tankhouse parameters in regard to the current efficiency and specific energy consumption.

Project content

The target of the project was to get a ranking of the most important tankhouse parameter regarding to the current efficiency, to analyse them and to define optimization potentials.

One of the first steps was an exact and reproductive process study onsite. Therefore the following electrolysis parameters using different anode qualities were measured:

- Geometry of the anodes
- Weight of the anodes
- Weight and form of the single anode remnants
- Roughness of the stainless steel
- Temperature and conductivity of the electrolyte
- Density of the electrolyte
- Chemical analysis of the electrolyte
- Distance between anode and cathode during the crop
- Current at each single cathode
- Voltage between each single anode and cathode
- Evaluation of the short detection
- Anode slime evaluation
- Visual documentations of the anodes, the anode scraps, and the cathode sheets
- Metallographic analysis on selected dendrites

Eight different anode qualities were chosen. Two anode qualities (quality F and R, see below) were used two times that means in total 10 cells (570 anodes) have been investigated. The anode qualities are standard ones used at Montanwerke Brixlegg. Anodes A were characteristic of a higher antimony content, B were characteristic of a higher lead content, anodes C were high in Pb, Sn, and Zn, anodes D were high in zinc, E were anodes coming from the smelter Kvohuty, F was a standard



chemical anode quality but during the casting a very high amount of mould wash was used, G were anodes with a higher oxygen content and finally R were the so called reference anodes.

To get comparable results of these measurements it had to be ensured having the most equal and comparable electrolysis conditions as possible. Therefore new starting sheets have been used for all ten cells. Also the electrolyte flow, the inhibitor addition and the regular handling parameters were similar in all cells.

Onsite Measurements

The Anode

The anode quality is a decisive factor for the effectiveness of a refining electrolysis. A high current yield, low energy consumption, few anode remnants, low specific manpower requirement, in addition to an excellent cathode quality depend to a great extent on the anode quality. Thereby, it is obvious that the anode quality has a decisive influence on copper refining electrolysis. The anode criteria are:

- Always same thickness and weight
- Equal surface properties on both sides
- Regular distribution of the impurities over the thickness
- No negatively influencing spray chemicals
- No bends and undulations
- No craters
- Perfect plugs preparation (milling) for good electrical contacts
- Content of enoble impurities as low as possible

The positioning and the adjustment of the electrodes have also a significant effect on the refining process due to the current density distribution.

Geometry of the Anodes

The shapes of all used anodes have been evaluated. At each single anode the thickness, height and length had been measured. Also remarkable surface mistakes, like “bubbles” and casting vibrations have been noted.



Anode Weight

Establishing the balance between fragile thin anode scraps and too heavy anode scraps which have to be remelted is problematic if the anode weight variation is too high. All used anodes have been weighted.

As an example, the average weight, the standard deviation, the maximum and minimum weight for the anode “R” charge is given in Table 1.

Table 1: Anode weight

	Average	Stand. Deviation	Maximum	Minimum
Reference	290 kg	0.94 kg	292 kg	287 kg

The anodes have an active height of 990 mm, a width of 945 mm and a thickness of 35 mm. Anodes with more or less weight have the same height and width, but a different thickness. This different anode thickness results in a variation of the distance between anode and cathode. As evaluated in /1/ this variation in the electrode distance results in different current density distribution over the entire cathode surface, which could cause dendrites.

Weight and Form of the single Anode Remnants

After the anode crop of 14 days the anode remnants have been weighted. The weight of the anode remnant is related to the dissolution behaviour of the anode and the effective anode current density.

The average of the anode remnants is about 14 % of the anode weight. The maximal value was about 40 % and the minimal about 6 %.

Cathodes

During all crops completely new stainless steel sheets were used for the cathode. The geometry and the roughness of the stainless steel starter sheets were at all cathodes the same good quality.

After the cathode crop of seven days the cathodes were lifted out, stripped and each single cathode was weighted. With these data a complete reconstruction of the current density distribution in the cell was possible.

Figure1 and Figure 2 describe the principle system which was used to combine all the different measured and calculated values.

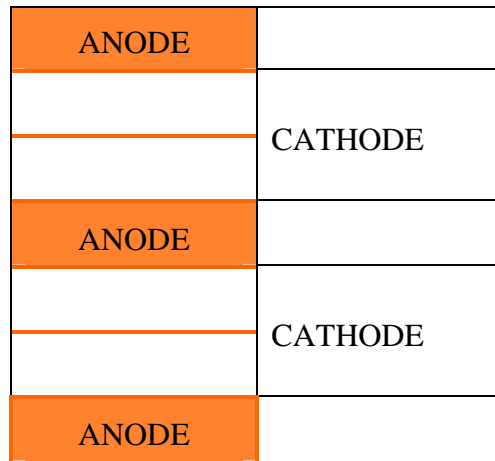


Figure 1: Sketch for the evaluation

In Figure 2 an example of the measured anode weights, cathode weights, anode remnant weights and all calculated values is presented

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
				air side										
45	290	51	17.59 %	95 %		83.79%								
				mould side	49	M			56	3 %			62	0 %
				air side		A	70	0 %			66	0 %		
46	290	59	20.34 %	98 %		83.10 %								
				mould side	48	M	x/7		52	0 %			53	0 %
				air side		A	65	5 %			69	0 %		
47	290	71	24.48 %	98 %		87.59 %								
				mould side	47	M	x/7		63	2 %			57	0 %
				air side		A	65	0 %	x/4,7		67	0 %		
48	292	57	19.52 %	99 %		82.88 %								
				mould side	46	M			55	0 %			55	0 %
				air side		A	66				69			
49	290	61	21.03 %	97 %		87.59 %								
				mould side	45	M	x/5,6		59	2 %			60	0 %
				air side		A	70	2 %			68	0 %		
50	292	53	18.21 %	98 %		89.00 %								

Figure 2: Results of the cell evaluation

A: Shows the number of the anode

B: Weight of the anode in kg

C: Anode remnant weight in kg

D: Percentage of the anode remnant weight of the anode weight



E: This value shows how many percent of the anode surface is left after the anode crop

F: Number of the cathode in the cell

G: Percentage of the produced cathode copper of one single anode

For anode number 46:

$$(70 \text{ kg} + 66 \text{ kg} + 52 \text{ kg} + 53 \text{ kg})/290 \cdot 100 = 83.10 \%$$

H: The cathode weight after the first cathode crop in opposite the anode air side

I: Percentage of the area with nodules of the total cathode

J: The cathode weight after the first cathode crop in opposite the anode mould side

K: Percentage of the area with nodules of the total cathode

L: The cathode weight after the second cathode crop in opposite the anode air side

M: Percentage of the area with nodules of the total cathode

N: The cathode weight after the second cathode crop in opposite the anode mould side

O: Percentage of the area with nodules of the total cathode

x/7: a dendrite has been removed (after the tank house operators have recognised it) at the 7th day of the cathode crop

x/4,7: a dendrite has been removed at the 4th and 7th day of the cathode crop

x/5,6: a dendrite has been removed at the 5th and 6th day of the cathode crop

This overview has been made for all ten cells. With this information many details could be detected. For an example a description of the results at anode number 47 is given:

The weight of the anode was 290 kg. After the anode crop of 14 day the anode remnant had a final weight of 71 kg, this related to 24.48 % of the anode had not been dissolved. 99 % of the anode surface is still seen at the anode remnant.

The related cathode sheets are one in opposite the anode air side which is cathode number 48/A and the other one in opposite the anode mould side which is cathode number 47/M. Here 134 kg at the cathode 48/M and 120 kg at cathode 47/A is predicted. In total these are 254 kg. The sum of these cathodes and of the anode remnant results in 325 kg, which is 35 kg more than the anode weights. Besides that during the first crop at the cathode 47/M dendrites were removed at the 7th day of the cathode crop. At both cathode sheets of the first crop dendrites and nodules had occurred, whereas the cathodes of the second crop are without dendrites and nodules.

After 2240 cathodes, 1130 anodes and 1130 anode remnants weighted, 6 weeks daily detailed measurements of current, voltage, distance of electrodes, density, conductivity and temperature of elec-



trolyte, shorts, more than 10,000 digital photographs for visual inspection, and more than 400 examples to detect the current density distribution an detailed discussion was carried out.

Discussion

During this test work – using 8 different anode qualities – the current efficiency was seven times higher then 97 %, and three times in the range between 90 to 95 %. Although the current efficiency was high, some effects or parameter have shown a significant correlation to the current efficiency. Some of these effects are discussed now.

Chemistry

The chemistry differences of the chosen eight different anode qualities were detected as the main reason for different current efficiencies. The variety has been between 91.5 % and > 99 %.

For these particular project a high tin value (> 0.1 %) and a low mole fraction rate I (MFR I < 0.5) were detected as the critical parameters.

The MFR I gives the ratio of molar mass of As to Sb and Bi.

Contacts

Using diagrams as shown in Figure 3 it was possible to highlight contact problems for cathodes. Figure 3 shows the current density distribution of one cell. For one stainless steel cathode two copper plates where weighted, one produced in opposite of the anode air side and one in opposite of the anode mould side. The weight of each plate was divided by the theoretical weight assuming a theoretical current density of 320 A/m² and 100 % current efficiency.

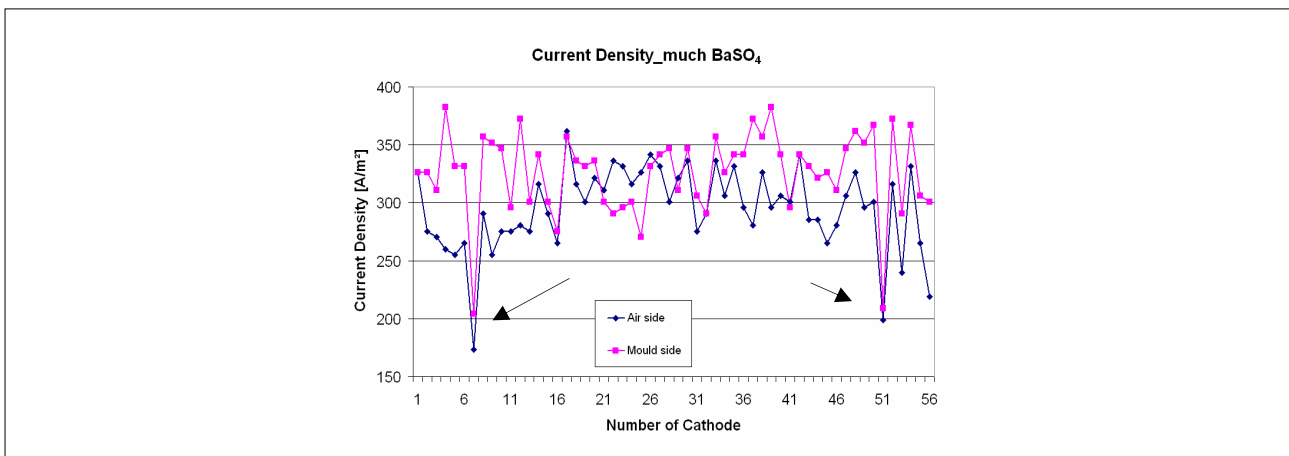


Figure 3: Current density distribution in one cell at each cathode



The two plates of cathode Nr. 7 and also of cathode Nr. 51 have shown very low weight compared to all other plates. Due to the fact, that the chemistry of all anodes in one cell is uniform, that the electrolyte is uniform and that the plates of one cathode are in opposite to two different anodes the conclusion can be done that the cathodes Nr.7 and 51 had some contact problems.

Contact problems occur also at anodes: Two anodes of the reference load showed a big difference in the anode scrap weight. While the anode scrap rate of R9 was 20.69 % of the anode origin weight, the anode scrap of the anode R23 had only 8.28 %. In the case of optical investigation of the two anode scraps also a strongly deviating form of the remnant anode body could be recognized.

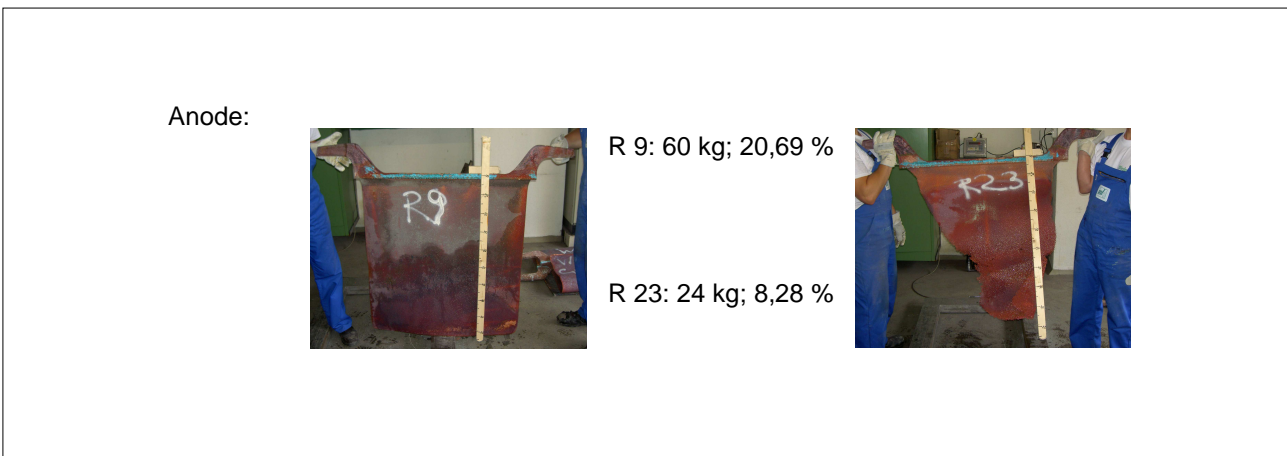


Figure 4: Anode remnants of anode Nr. R9 and R23

The anode scrap from anode R9 were between the cathodes number 49 and 48. The current efficiency of these cathodes was lower compared to all others. This effect was seen during both cathode crops, the produced cathodes had no dendrites and a good surface.

After evaluating the results that

- the current density was lower in both cathode crops
 - the current efficiency was lower
 - at the cathodes no dendrites were detectable
- only the contacts could be responsible for this high amount of anode scrap.

Air-Mould-Side

For one stainless steel cathode two copper plates are produced, one in opposite of the anode air side and one in opposite of the anode mould side. The current density distribution of all 2240 weighted copper sheets shows a difference between plates in front of the anode air side compared to plates which are opposite anode mould side.

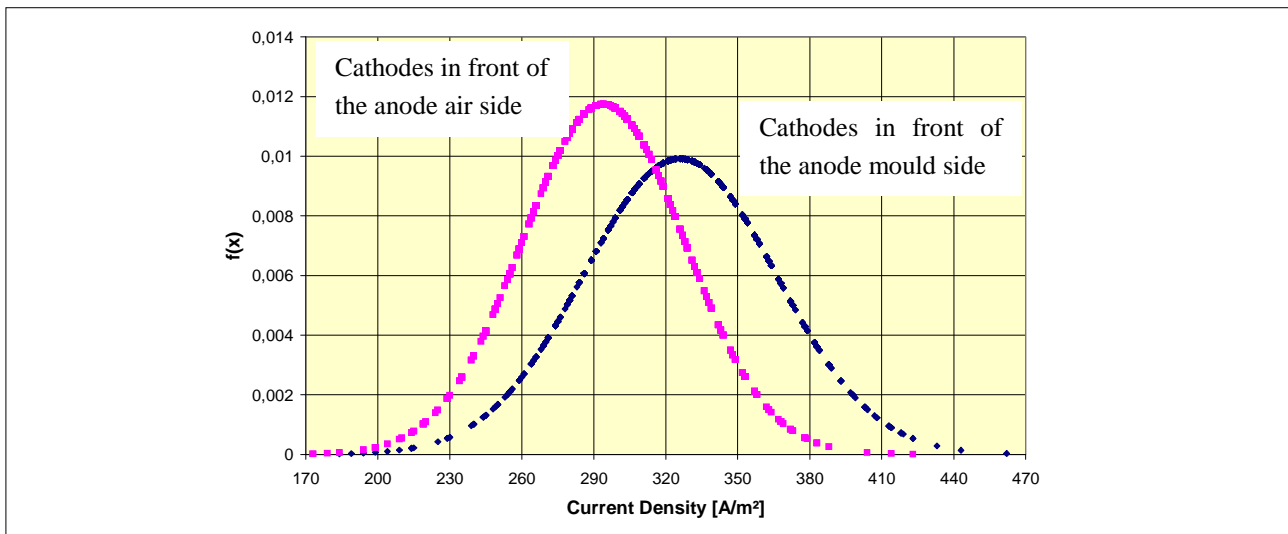


Figure 5: Current density distribution of the cathodes of the single cell

In Figure 5 it is mainly shown that the current density at the cathodes which are in front of the anode air side is at average lower, but also the deviation is much smaller. While the current density at the cathodes in front of the mould side is in average higher, but the deviation is higher, too. Finally the influence of the two different anode sides is clearly shown. The distances between the electrodes were constant and equal at both sides.

Anode and Cathode Distance

The distance measurement was limited to a certain voltage and current maxima and/or - minima. If one of these extreme were recognised the distance measurement was done. If a short circuit occurred the distance between anode and cathode was measured, too. In the evaluation of the current density distributions the space incorrectness is clearly recognizable.

Figure 6 shows some examples of the variation of current density resulted of no equal distances between anode and cathode. These variations cause a current density variation to more than 100 A/m².

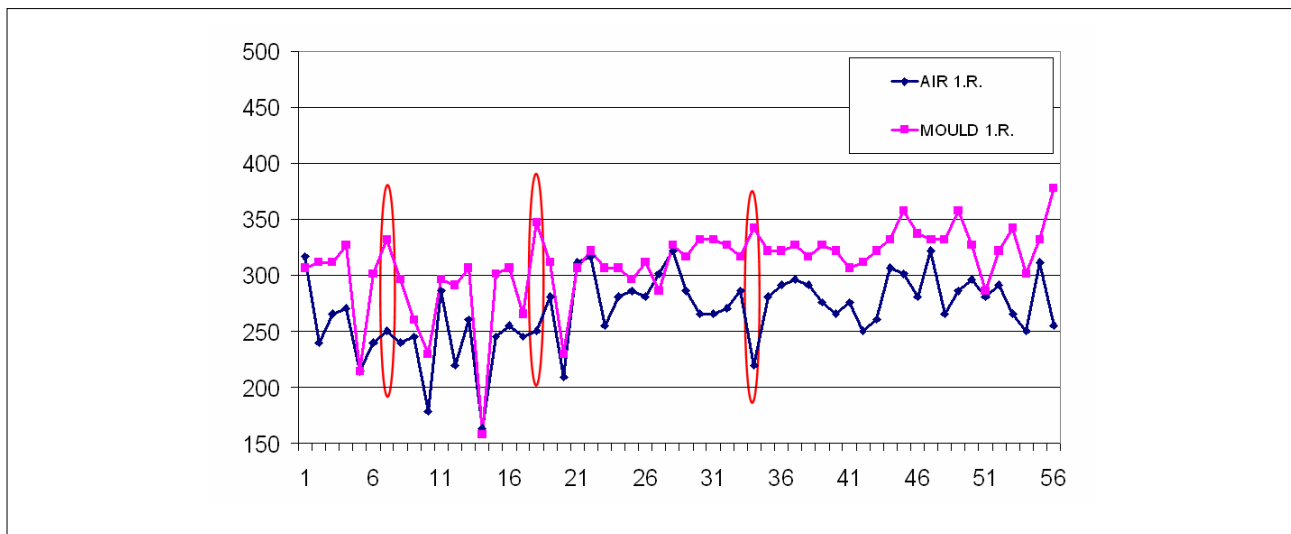


Figure 6: Current density distribution in one cell at each cathode

Shorts

During these investigations the shorts have been detected, too. Therefore the operators recorded when and where they removed a dendrite. Afterwards these data were summarized and it was possible to give a conclusion about the occurrence and the frequency of the short-circuits.

Conclusion

The goal of the available work was the valuation of different parameters on the current efficiency with the use of different anode qualities. Based on plenty of data and information and a very close cooperation to all operators and engineers at Montanwerke Brixlegg AG, it was possible to detect some of the main parameters and to evaluate the importance for a high current efficiency.

In cooperation with Montanwerke Brixlegg some projects were defined to guarantee very high current efficiency in future.

References

- [1] FILZWIESER, I., (2005.): The analysis and mathematical modelling of the parameters influencing cathodic deposits in copper refining electrolysis; Ph.D. Thesis, Montanuniversität Leoben, Leoben