Economic feasibility analysis of construction of high amperage aluminium smelters

S. Akhmedov[1], V. Kozlov[2], V. Rozanov[3], M. Gorlanov[4]
1. General Director
2. Technical Manager
3. Deputy General Director on Foreign Relations
4. Manager
ALCORUS Co Ltd, Saint Petersburg, Russian Federation
Corresponding author: office@alcorus.ru

Introduction

Since the 1970's we have seen continuous amperage increase from 180 kA to 600 kA. It is considered that amperage increase allows reducing specific power consumption, unit capital costs on the construction and labor costs on the maintenance as well as decreasing the harmful emissions to the atmosphere.

The paper gives the results of the investigations related to the specific power consumption and current efficiency based on data published in Light Metals for the period of 1984-2015. The investment calculations related to the construction of an aluminium smelter are done while varying parameters on specific power consumption, capital costs on construction, labor costs on operation, discount rate and service life of the pots. The conclusions are made on the substantiation of using high-amperage pots.

Keywords: High amperage smelters; economic analysis, capital cost.

1. Analysis of process parameters of the pre-bake anode pots based on publications in Light Metals for the period of 1984-2015.

The history of electrolytic aluminium production that begins in 1886 with introduction of the technology developed by Hall-Heroult, and with start-up of the first smelter based on this technology in 1888 in Neuhausen, Switzerland, could be presented as road map of updating the designs of aluminium pots. There are three types of the pots: pre-bake pots, vertical stud Soderberg pots and horizontal stud Soderberg pots.

During the evolution of the pot design, the pre-bake pots turned out to be the most viable on the basis of process, economic and environmental parameters. The common trend in the design of prebake pots testifies that since 1970s and till 2015 continuous amperage increase has been taking place in the pots from 180 kA to 600kA. Actually some developers propose to continue the amperage increase to 700 кА and higher. Such trend of increasing the amperage in the prebake pots is substantiated by the following main requirements:

1. Reduction in specific power consumption,
2. Reduction in unit capital costs on the potrooms construction,
3. Reduction in relative rates of harmful gas emissions to the atmosphere.

The construction of any primary aluminium smelter passes through the same stages: scientific investigations, engineering, construction, commissioning and operation. Every stage forms its own database that includes process parameters (specific power consumption, current efficiency, emissions to the atmosphere), information about the costs on equipment, on construction of the buildings and facilities as well as information about unit costs related to the aluminium smelter construction.

All these parameters that reflect the real data on the smelter construction are usually confidential and as a rule they are not published in public media. Data that are published in commercial overviews of some publishers and information providers like Aluminium-Verlag Marketing & Kommunikation, Brook Hunt, CRU, Metal Bulletin, and others do not usually have any references to the sources of the information and do not give any details that would be sufficient to carry out any methodologically feasible comparative analysis of the achievements in technological parameters and capital costs related to the construction of an aluminium smelter. This does not allow analyzing documentary the technological and economic advantages of introduction of high-amperage pots.

At the same time over the last 40 years the TMS conference has been publishing information about pilot-industrial tests and industrial operation of aluminium pots. This information is exposed as scientific articles with a certain evidence-based information format. The analysis of the information, published in Light Metals, can have some features of interest as it allows identifying the results achieved in the operation of aluminium pots. It is believed that the reduction in specific power consumption is the most important factor in the trend of amperage increase; due to this the Figure 1 gives the data on the specific power consumption by the pots of different types. These data were published in Light Metals 1984-2015 [1-52].

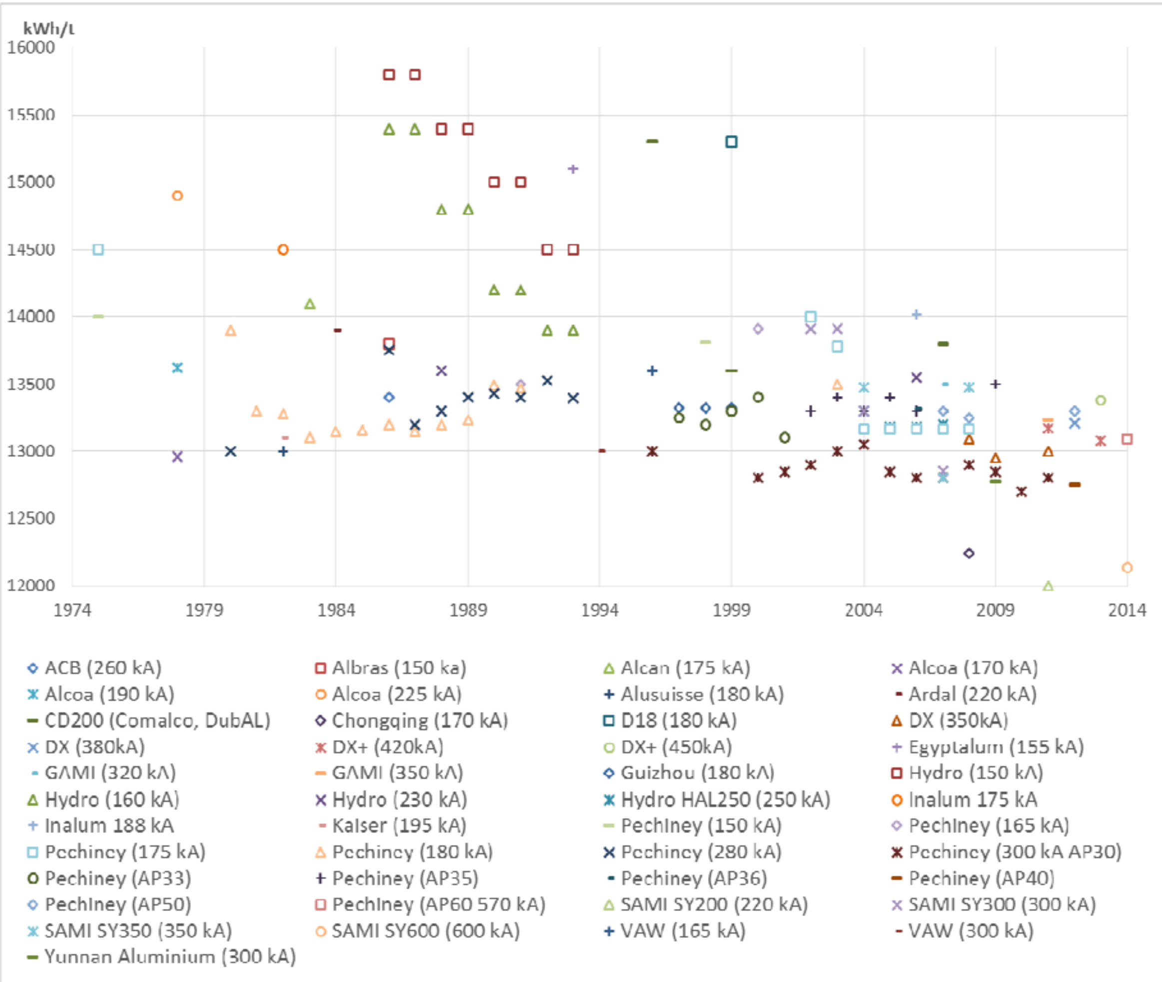

Figure 1. Specific power consumption by the pots of different types.

Based on this information it is possible to try to reveal certain relationships. For example, Figure 2 summarizes data on specific power consumption by the pots with different amperage:

5. References

1. E. Basshard et al, EPT 18: The new 180kA pot of Alusuisse, Light Metals 1983, pp 596-605
2. E.B. Sarcinelli et all, The construction and operation of an aluminium plant in the amazon region, Light Metals 1987 pp 215-229;
3. H. Medina et al, The Venalum 230kA Potline, Light Metals 1989, pp 345-351;
4. B. Langon and Jm. Peyneau, Current efficiency in modern point feeding industrial potlines, Light Metals 1990, pp 267-274;
5. V. Katic and I. Kralj, From 89 to 95 modernization of potline im Sibenik, Light Metals 1992, pp 333-336;
6. M. Deshaies et al, An overview of ABI's experience with Pechiney 180 kA Cells, Light Metals 1992, pp 337-341;
7. O. Mertin, G-line in St.Jean De Mauriene, Six operation Years, Light Metals 1992, pp 343-346;
8. M.F. El-Demerdash et al, Modeling of metal topography and flow regions in working prebaked aluminium pot, Light Metals 1993, pp 369-374;
9. T.A. Utigard et al, Visualization of the Hall-Heroult process, Light Metals 1994, pp 233-240;
10. D. Vogelsand et al, Development of 300 kA reduction cell: application of simulation tools for the conceptual design, Light Metals 1994, pp 245-251.
11. T. Moen et al, Review of the retrofit program for brebake potlines of Hydro Aluminium, Light Metals 1994, pp 413-415;
12. M. Reverdy et al, AP 30 pot technology and experience gained from the recently started potlines, Light Metals 1995, pp 405-411;
13. D. Vogelsang et al, Retrofit Soderberg smelter at ALUSAF Bayside plant. Part - 1 Conceptual design and engineering Light Metals 1996, pp 327-333;
14. J.-P.Aussel et al, Commissioning of Alusaf Hillside smelter reduction pots, Light Metals 1997, pp 227-232;
15. G.P. Bearne et al, The CD200 Project - The development of a 200 kA Cell design from concept to implementation, Light Metals 1997, pp 243-246;
16. S. Feng et al, Development of High Amperage Prebake Cells in China, Light Metals 2000, pp 171-178;
17. A.J.M. Kalban et al, Reduction cell technology development at Dubal through 20 years, Light Metals 2000 pp 215-220;
18. L. Fiot et al, Tomago aluminium AP22 project, Light Metals 2004, pp 173-178;
19. G.E. da Mota and J.E.M. Blasques, Process improvements to raise the line current at Albras, Light Metals 2004, pp 185-190;
20. S. Haibo et al, Henan HongKong Longquan Aluminum Co.Ltd., China -- Growing Up, Light Metals 2004 pp 233-236;
21. O. Martin et al, The Next Step to the AP3X-HALE Technology: Higher Amperage, Lower Energy and Economical Performances, Light Metals 2006, pp 249-254
22. Dante Sinaga et al, Technical Improvement in Inalum, Light Metals 2007, pp 237-242;
23. Haibo She et al, Henan Hongkong Longquan Aluminum Co. Ltd., China-Second Phase, Light Metals 2007, pp 249-252;
24. Oliver Martin et al, The Latest Developments of Alcan's AP36 and ALPSYS Technologies, Light Metals 2007, pp 253-258;
25. Abdelhamid Meghlaoui et al, Anode effect and Specific Energy Reduction through Cell Control and Operating Parameters Optimization, Light Metals 2007, pp 399-404;
26. Ben Benkahla et al, Last Development in AP50 Cell, Light Metals 2008, pp 451-456;
27. Marvin Bugge et al, Expansion of the Potline in Slovalco, Light Metals 2008 pp 261-266;

28. Oliver Martin et al, The FECRI Approach and the Latest Development of AP3X Technology, Light Metals 2008, p255-260;
29. Cus Zlatko, and Avgust Sibila, 20 Years of continues improvements in TALUM Smelter, Light Metals 2008, pp 467472;
30. Z. Ming et al, The Advancement of New Generation SY350 Pot, Light Metals 2009 pp 377-379;
31. M. Al-Jallaf et al, Evolution of CD20 Reduction Cell Technology towards Higher Amperage Plan at Dubal, Light Metals 2009, pp 451-454;
32. B. Kakkar et al, 2008: A Milestone in the Development of the DX Technology, Light Metals 2009, pp 359-364;
33. B. Benkahla et al, AP50 Performances and New Development, Light Metals 2009, pp 365-370;
34. L. Fiot et al, Development of the AP39: The New Flagship of AP Technology, Light Metals 2010, pp 333-338;
35. A. Zarouni et al, DX Pot Technology Powers Green Field Expansion, Light Metals 2010, pp 339-344
36. Z. Jia et al, The Pot Technology Development in China, Light Metals 2010, pp 349-354;
37. L. Jie et al, Industrial Test of Low-voltage Energy-saving Aluminum Reduction Technology, Light Metals 2010, pp 399-404;
38. W. Ziqian et al, Study of Surface Oscillation of Liquid Aluminum in 168kA Aluminum Reduction Cells with a New Type of Cathode Design, Light Metals 2010, pp 485-488
39. Y. Xiaobing, and T. Qinghong, Development and application of a multivariate process parameters intelligence control technology for aluminum reduction cells, Light Metals 2010,p523-527;
40. O. Martin et al, Low Energy Cell Development on AP Technology, Light Metals 2012, pp 569-574;
41. P. Coursol et al, The Transition Strategy at Alouette towards Higher Productivity with a Lower Energy Consumption, Light Metals 2012, pp 591-594;
42. J. Zhou et al, Depth Analysis and Potentiality Exploitation on Energy-Saving and Consumption-Reduction of Aluminum Reduction Pot Light Metals 2012, pp 601-606;
43. D. Zhou et al, Development and Application of SAMI's Low Voltage Energy-Saving Technology, Light Metals 2012, pp 607-612;
44. A. Al Zarouni et al, DX+, An Optimized Version of DX Technology, Light Metals 2012, pp 697-702;
45. A. Al Zarouni et al, The Successful Implementation of DUBAL DX Technology at EMAL, Light Metals 2012, pp 715-720;
46. P. Thibeault et al, Rio Tinto Alcan AP4X Low Energy Cell Development, Light Metals 2013, pp 543-548;
47. M. Bastaki et al, DUBAL Cell Voltage Drop Initiatives Towards Low Energy High Amperage Cells, Light Metals 2014, pp 451-456;
48. D. Zhou et al, CHINALCO 600kA High Capacity Low Energy Consumption Reduction Cell Development, Light Metals 2015, pp 483-488;
49. A. Zarouni et al, Development History and Performance of Dubal DX+ Demonstration Cells, Light Metals 2015, pp 489-494;
50. M. Forté et al, Arvida aluminum smelter - AP60 technological center, start-up performance and development of the technology, Light Metals 2015, pp 495-498.