Historical Development of Aluminium Production Technologies in Germany

Horst Peters
Business owner
Aluminium Technology Consultants, Bonn, Germany
Corresponding author: horst.d.peters@web.de
https://doi.org/10.71659/icsoba2024-al001

Abstract

Ørsted in 1824 and Wöhler in 1827 are credited with the discovery of aluminium, which they obtained from aluminium chloride, the former in reaction with potassium amalgam, and the latter with pure potassium: $AlCl_3 + 3K \rightarrow Al + 3KCl$. Initially, both likely obtained an aluminium alloy with some potassium. In 1827, Wöhler obtained aluminium powder, but continued his research, and in 1845 he was able to produce small pieces of the metal and described some of its physical properties. For this, he is credited with the first isolation of the metal in its pure form.

The aluminium discovery initiated an aluminium hype and people from all over the world came to Göttingen, including the Frenchman Henri Sainte-Claire Deville and Frank Jewett from USA. Jewett motivated his student Charles M. Hall to develop a process for industrial production of aluminium. In Wöhler's Institute worked Alfred Wilm. He developed the age hardening of aluminium alloys and made aluminium a versatile material suitable to build planes.

Bunsen obtained in 1854 aluminium in an electrolytic process with the power source of the "Bunsen Element". Industrial production of aluminium by electrolysis was not possible until after Siemens found in 1866 the electrodynamic process for continuous generation of electricity. But Bunsen had already focussed on competitive alumina production. Two of his Heidelberg students were successful. Georg Otto Guilini and Karl Josef Bayer were able to digest bauxite in liquid potassium at a very cost competitive basis. Bayer later used sodium hydroxide (caustic soda) for alumina production, and this is known as the Bayer process. Bielfeldt in 1966 invented the tube digestion process for high pressure, high temperature digestion of monohydratic bauxites. The Bayer process in combination with the Hall-Héroult process enabled the industrial production of aluminium in a competitive way - till now.

In 1936, Roth developed in Hannover a water-cooled mould to cast extrusion billets and rolling slabs. A further development was Hot Top Moulds.

In more recent times, Germany contributed to the development of Hall-Héroult cell technologies with continuous prebaked anodes. A special retrofit package for smelters with short payback periods was developed with items like debottlenecking of busbar systems, ELAS's Pot Control System and various alumina transport and distribution systems.

Keywords: Wöhler process, Bunsen electrolytic process, Bayer process, Tube digestion, Aluminium reduction technology.

1. Historical Developments

Ørsted in 1824 and Wöhler in 1827 are credited with the discovery of aluminium, which they obtained from aluminium chloride, the former in a reaction with potassium amalgam, and the latter with pure potassium:

$$AlCl_3 + 3K \rightarrow Al + 3KCl.$$

1.1 Wöhler

Wöhler was born on 31st of July 1800 in Frankfurt. He studied medicine in Heidelberg from 1820 to 1823 and additionally chemistry from 1821.

Figure 1. Friedrich Wöhler.

In the years 1823 and 1824, Wöhler worked with Berzelius in Stockholm, at that time the highest competence in chemistry. On his way back to Germany, Wöhler stopped from 27th to 30th September 1824 in Copenhagen to meet Ørsted.

Ørsted worked from 31st May 1824 to 31st May 1825 on the discovery of aluminium from aluminium chloride. In many trials Ørsted was not able to obtain pure aluminium, but most likely an aluminium alloy with the elements used in the experiment, mercury and potassium; the metallic shiny lump of material he obtained looked like tin. In 1820, Ørsted discovered magnetism. He focussed his research further on this item and the related electricity.

Ørsted informed Wöhler about his research to obtain aluminium and recommended him to "follow up this matter" [1].

In 1827, Wöhler repeated in Berlin the Ørsted trials with the same result [2]. Wöhler became in 1836 professor of chemistry in Göttingen and in 1845 he repeated his tests replacing potassium amalgam with pure potassium, and with this so-called "Wöhler process" he was able to obtain a small quantity of liquid aluminium. These pieces of aluminium made it possible to define the chemical and physical characteristics of aluminium. For this, Wöhler is credited with the first isolation of aluminium in pure form. When Wöhler published his results in 1845 in "Annalen der Chemie und Pharmazie", an international aluminium hype began [3].

On 6th of February 1854, the Frenchman Henri Sainte-Claire Deville reported at the Academy of Sciences about his success to obtain aluminium. By replacing potassium by sodium, he was able to make a few kg of aluminium in good quality. Because Deville did not mention that he applied the Wöhler process, a priority dispute started.

The dispute was settled by honouring Wöhler with the French State medal by Napoleon III and he was called "père d'aluminium". Wöhler recognised that Deville achieved bigger quantities of pure aluminium and gave the discovery public attention. Both became later friends and performed, in 1857, in Göttingen tests with boron, silicon and titanium [4].

Figure 8. Norðurál smelter, Iceland.

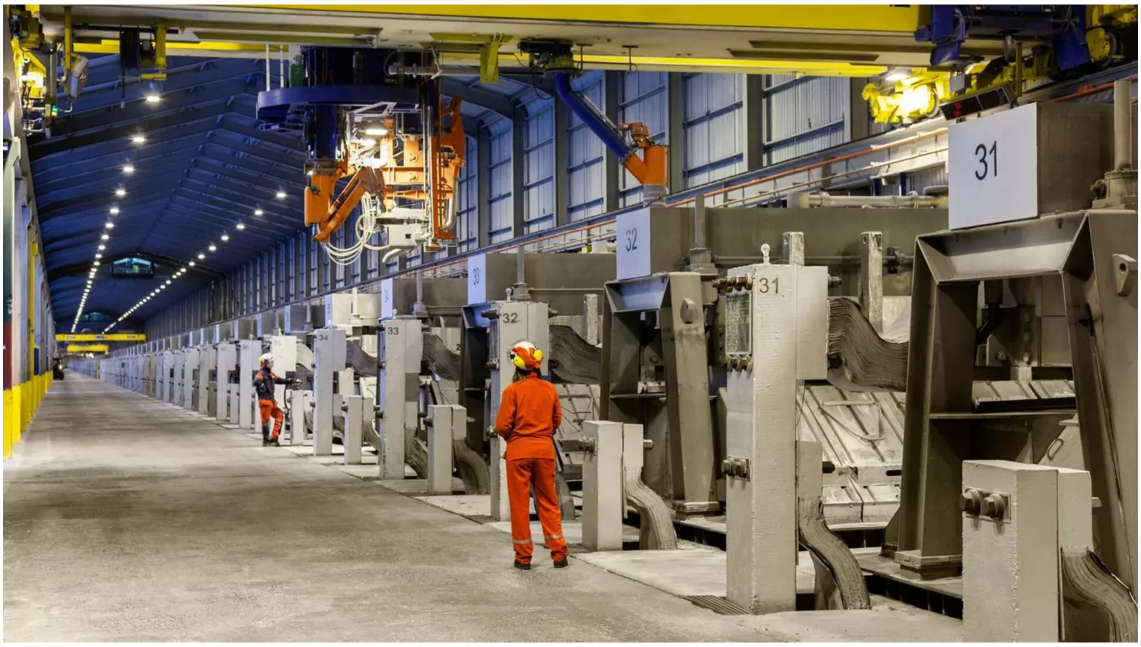

Figure 9. A potroom with VAW's CA 240 cells in Norðurál smelter, Iceland [27].

4. References

1. Letter Wöhler to Berzelius, Lübeck, 8th October, 1824, published by Wallach, Göttingen, 1901.
2. F. Wöhler, Über das Aluminium, *Poggendorfs Annalen* 1827 (Bd. 11), 146-161.
3. F. Wöhler, Zur Kenntnis des Aluminiums, *Annalen der Chemie und Pharmacie*, Heidelberg, 1845 (Bd. 53), 422-426.
4. Letter Wöhler to Liebig, Göttingen, 6th February, 1857, published by Lewicki: 1983.
5. Allan S. Russel, Pitfalls and Pleasures in New Aluminum Process Development, *Metallurgical Transactions B*, Vol. 12B, June 1981, 203-215.

6. https://www.hydro.com/en/global/media/on-the-agenda/hydros-roadmap-to-zero-emission-aluminium-production/halzero-zero-emission-electrolysis-from-hydro/ (accessed on 13 July 2024).
7. A. Wilm, Veredeln von Aluminiumlegierungen, *German Patent* 244554 v. 20th March, 1909.
8. R. Bunsen, Notiz über die elektrolytische Gewinnung der Erd- und Alkalimetalle, *Poggendorfs Annalen* 1854 (Bd. 92), 527-529.
9. K. Bayer, Darstellung von Tonerdehydrat, *German Patent* 43977 v. 17th July, 1887, and 65604 v. 31st January, 1892.
10. Giulini Company Archives, Stadtarchiv Ludwigshafen.
11. Horst Peters, Tube Digestion – Late success of a VAW technology, *Proceedings of 35th International ICSOBA Conference*, Hamburg, Germany, 2 – 5 October, 2017, *Travaux* 46, 145-153.
12. K. Tusche, Rohraufschluss, *German Patent* 1592194 v. 6th May, 1967.
13. Theodor Beisheim, Allan Borges and Alessio Scarsella, Metso Outotec's 5th Generation of CFB Alumina Calciners – Optimized Process and Equipment Design, *Proceedings of the 40th International ICSOBA Conference*, Athens, 10 - 14 October 2022, *Travaux* 51, 459-466.
14. L. Reh, Hydratcalcination, *German Patent* 1592194 v. 16th June, 1967.
15. Birthe A. Scholemann and Siegfried Wilkening, Reduction Cell with Continuous Prebaked Anodes - A New Approach, *Light Metals* 2001, 167-172.
16. J. Ghosh, A. Steube and B. Levenig, From 110 to 175 kA: Retrofit of VAW Rheinwerk, Part 2: Construction and Operation, *Light Metals* 1997, 239-242.
17. Jeffrey Keniry, Duncan Hedditch and Chris Jones, The Continuous Prebaked Anode Cell – a Pathway to Carbon Capture in Aluminium Production, *Proceedings of the 41st International ICSOBA Conference*, Dubai, 5 - 9 November 2023, *Travaux* 51, 1395-1408.
18. Morten Karlsen et al., New Aerated Distribution (ADS) and Anti Segregation (ASS) Systems for Alumina, *Light Metals* 2002, 590-595.
19. Andreas Wolf, Peter Hilgraf, Michael Altmann-Rinck, A new alumina distribution and feeding system for aluminium reduction cells, *Light Metals* 2007, 223-228.
20. Jan Paepcke, Torsten Tietke and Arne Hilck, Challenging tailormade solutions, implementing new conveying equipment into existing systems, *Proceedings of the 39th International ICSOBA Conference*, Virtual, 22 - 24 November 2021, *Travaux* 50, 945-951.
21. C. Duwe, K. von Geldern, The Moeller direct pot feeding system for a smooth and constant pneumatic transport of secondary alumina to the electrolyte cells, *Proceedings of the 6th International Alumina Quality Workshop* 2002, 228-232.
22. B. Levenig, ELAS – VAW's cell control automation system, Light Metals 1995, 387-389.
23. Volker von der Ohe, Conversion of the AP 14 potline at Aluminij D.D. Mostar from side to point feeding, *Light Metals* 2003, 387-391.
24. E. Lossack, Vacural, vacuum die casting, *German Patent* 3041340 v. 3rd November, 1980.
25. D. Vogelsang, M. Segatz, C. Droste, P. Baekler, and R. Stücher, Development of a 300-kA reduction cell: Application of simulation tools for the conceptual design, *Light Metals* 1994, 245-251.
26. ABB, 17% improved productivity for Nordural with ABB electromagnetic stirring https://new.abb.com/metals/abb-in-metals/references/nordural-improves-productivity-by-17-with-abb-electromagnetic-stirring (accessed on 17 July 2024).
27. Editorial team, Exploring the 'Aluminium Paradox', International Aluminium Journal, Newsletter, 24 July 2024, https://www.aluminium-journal.com/exploring-the-aluminium-paradox?utm_source=Newsletter&utm_medium=email&utm_content=Exploring (accessed on 24 July 2924).