Excess Bath Material - Sustainable Solutions to an Environmental Liability

Andreas Schwarz[1], Andreas Waser[2], Kanishk Shah[3], James Read[4], Drago Juric[5] and Joe Kazadi[6]
1. Chief Executive Officer
2. Chief Operating Officer
3. Manager Raw Materials
4. Head Raw Materials Trading
Bathco AG, Zürich, Switzerland
5. Chief Technology Officer
6. Chief Executive Officer
Metsol Ltd, Zürich, Switzerland
Corresponding author: andreas.schwarz@bathco.ch

Abstract

The problem of excess bath material is a growing concern to the global aluminium smelting industry. Bath material (bath) is the electrolytic material used in the production process for primary aluminium. Bath is generated in-situ during the production of aluminium, where sodium compounds combine with the aluminium fluoride (AlF_3) added to reduce electrical energy requirements. The final mixture consists primarily of cryolite (Na_3AlF_6), excess aluminium fluoride, calcium fluoride (CaF_2), alumina (Al_2O_3) and other minor elements. The exact amount of excess bath generation varies with different raw materials used and depends on pot life. Under normal circumstances the excess generation far exceeds the consumption (e.g., in pot relining) of a smelter. Hence a typical smelter will produce a continuous surplus of bath for most of its lifetime. With the strong growth of the primary aluminium capacity over the past two decades, the amount of excess bath has increased dramatically, with demand, mainly coming from new smelters for their start-ups, being outstripped by the excess generation. This has created a problem for the industry as stocks increase and become burdensome - and potentially an environmental liability. This structural change in the over-supply of bath happened gradually over the past years and has so far received little attention. As the aluminium industry moves rapidly towards a more sustainable and greener future, the option of landfill or long-term storage becomes unacceptable in many regions. This paper gives a historical and future overview of the global situation of excess bath material and its key drivers. The team of authors consists of technical experts of the electrolysis process, aluminium industry experts and specialists who have developed bespoke solutions to remove, upcycle and repurpose this excess material.

Keywords: Aluminium electrolysis by-products, Sustainability of aluminium production, Bath material, Cryolite, Solution to growing bath inventories.

1. Introduction

Bath is a by-product of the aluminium electrolysis process. The generation of bath globally is growing much faster than its traditional consumption or recycling pathways can support, hence the excess. Furthermore, because it is a fluoride bearing compound, bath is an environmentally challenging material to handle due to its status as a marine pollutant, and is costly to landfill. This is a growing problem that the aluminium industry globally has paid little attention to. However, the traditional markets cannot absorb the continuously growing oversupply.

Bathco, a leading bath trader and processor has developed alternative and sustainable solutions to consume the excess bath, able to treat any bath material regardless of quality or location. These innovative and proprietary solutions would be able to process all existing Bath inventory.

2. Discussion

Bath has become a growing issue for the primary aluminium industry because its generation continues to grow rapidly in line with the global growth in aluminium production, and smelting performance improvements. However, the aluminium industry has not focused on finding a solution for it due to its low economic value.

2.1 Growth of Excess Bath

Today, most smelters generate excess bath. Historic literature suggests that the typical rate of generation was between 4.2 kg and 7 kg/t Al [1] but given todays' predominant usage of graphitized cathodes, the typical net excess is now greater than 10 kg/t of aluminium produced.

Bath is the electrolyte used to dissolve alumina. There are a variety of qualities of bath, but a typical composition as marketed by Bathco is shown in the tables 1 and 2. Bath material is a by-product of the aluminium electrolysis process, the analysis is thus typical and based on composite sampling. Typical packaging size is 1-1.5 t in polypropylene big bags.

Table 1. Typical specification of chemical composition of commercial pure tapped bath material marketed by Bathco.

	Min (%)	Max (%)
Na_3AlF_6	77	80
AlF_3	11	14
Al_2O_3	3	5
CaF_2	4	5.5
Fe_2O_3	<	0.05
SiO_2	<	0.05
MgF_2	<	0.02
P_2O_5	<	0.02
C	<	0.15

Table 2. Typical bath size distribution, coarse grain size.

	Min (%)	Max (%)
0 – 20 mm	100	20
0 – 4 mm	40	60
0 – 1 mm	30	35

Bath consists primarily of up to 80 % cryolite. The generation and consumption of bath is therefore governed by the equation of cryolite generation, Equation (1):

$$3Na_2O + (4 + x)AlF_3 \rightarrow 2Na_3AlF_6 + Al_2O_3 + xAlF_3 \quad (1)$$

  - In a stabilised form, this could be disposed of in an industrial waste landfill at minimal cost should there be a need to do so
- Upcycled into other industrial uses, lowering overall carbon footprint

8. Conclusions

Over the years, the primary aluminium industry has outgrown its own solution for the excess bath material it produces. The existing previous paradigm solution cannot absorb the industry's growing output and hence the situation has shifted from one of bath material balance being in equilibrium to a one where there is a clear supply excess. Therefore, new solutions were urgently needed.

This paper reports that, over the past decade, Bathco has developed several applications in various industries leading to effective and sustainable solutions for the excess bath issue. Bath material, regardless of quality, quantity, and classification, will be fully upcycled under total compliance with environmental regulations.

Bathco is currently putting in place additional capacity to be able to consume the increasing generation of bath and start reducing stocks of bath material. Bathco has set its clear goal to be the market leader in providing best possible and carbon neutral solutions to the excess bath challenge. With a global network of processing facilities, direct smelter contacts and centralised logistical operations team, Bathco manages transportation and handling of materials seamlessly with smelter operations.

9. References

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