An approach to a sustainable aluminium smelter design

Stephan Broek[1], James Farrell[2], Muna Alamoodi[3], Nadia Ahli[4], Milton Khan[5]

1. Director Environmental Engineering and Technology, Hatch Pty Ltd, Abu Dhabi
2. Senior Consultant, Hatch, Mississauga, Canada
3. Head of Environment, EGA - Jebel Ali Operations
4. Lead Engineer - Process Development – EGA Technology Development & Transfer
5. Senior Supervisor – Environment, EGA - Jebel Ali Operations

Corresponding author: sbroek@hatch.ae

Abstract

When engineers start developing the concept of a new aluminium smelter, in many cases they look back at configurations that are used before or otherwise known. Local constraints and conditions are taken into account after which the design is optimized; however, this optimization is mainly done to save costs. In the future we should expect that new requirements will be introduced that will be part of the design process. One such requirement is Sustainability. With that is meant that the conceptual design of a smelter is such that it optimally uses resources such as energy and water, minimises air emissions and also applies a high standard of recycling and reuse of otherwise discarded materials. In this paper proposals are made to incorporate sustainable technologies, practices and other means of satisfying the sustainability requirement. An important starting point is that the integration of sustainability is achieved with no constraints of capital costs so that the creative process is optimal. The objective of this paper is to demonstrate that the design of a smelter can include a high degree of sustainable technologies and practices. These ideas then may be considered in future designs of new smelter projects.

Keywords: Sustainable development; aluminium smelter; design.

1. Introduction

The design of aluminium smelters is considered to be optimized. It rarely changes dramatically if one takes a look at recent smelter designs. It goes back to the study phases of projects where engineers start developing the layout of a smelter. The layout changes depending on some local aspects but fundamentally there is not a lot different between projects. Also the choice of technologies within the design of a smelter is fairly standard. Whether it is a paste plant, a baking furnace or a set of potrooms, the technological choices are fundamentally the same.

Project development teams and engineers are pushed into corners where they are often not allowed to be too creative. Very often engineers go back to proven, but older designs rather than taking a fresh look at things. It must be recognized that projects are driven by capital costs and that owners, for good reason, drive this behaviour.

In this paper we want to focus on the sustainable design of a smelter. It involves introducing technologies and other aspects that would make the design of future smelter more sustainable, ‘greener’ so to speak. Some aspects that will be reviewed are readily available, while others still are ideas or need industrialization. This does not hold us back in considering it.

The purpose of the paper is an attempt to refresh everyone’s thinking that we can do things different when it comes to the sustainable design of a smelter. Constraints such as capital costs may not lead to a full fledges roll out but by means of this paper we hope to establish a changing trend of including some of these more sustainable technologies and techniques in new smelter designs in the long term.

2. Boundaries

In our review we have to establish some boundaries so that it remains meaningful and to the point. It also keeps us focused on the main goal, which is to challenge the conceptual smelter design.

In our scope we consider the following:

- Port facilities for receiving raw materials and shipment of products,
- A carbon plant complete with storage, green anode plant, anode baking furnaces and rodding shop,
- A reduction plant complete with alumina transport, potrooms, and gas treatment centres,
- A casthouse with holding furnaces, casting machines and associated areas to make products ready for shipment,
- General areas for maintenance, administration and other supporting facilities.

This all forms the design of a modern smelter complex.

In the review we stay away from power generation. It has indeed a large impact on a smelter but there are different forms of power generation and also in different regions the approaches will be very different. So relative to the design of a smelter, it would make it more complex and the possibilities are enough for another paper. Therefore it is excluded.

In this paper we do not test any of the available technologies for sustainability whether this is for anode production or electrolysis, etc. This paper focuses on what else can be done or what general improvements can be made by all.

3. Considerations for sustainable design

Sustainable design is based on principles of sustainable development. This is defined in dictionaries in simple terms as "*economic development that is conducted without depletion of natural resources*". To consider the outcome of the review to be sustainable, we have to follow some key guidelines that define sustainability. These are:

- Lower energy consumption and improved energy efficiencies,
- Reductions in the use of resources such as water or land,
- Minimizing air emissions,
- Reuse or recycling of discarded materials,
- Improved productivity (do more with what you have with lesser use of resources),

It is very clear that sustainable development is also economically driven and this is not forgotten, but for the purpose of the paper we place this aside in order not to slow down the creative process that we are after. All economic attributes will be taken into account when any sustainable design aspects are to be considered in future developments.

In the paper we will not specifically go into the social aspects that are part of sustainability; however, by considering the technologies and operating practices that are presented, the social aspects are positively impacted by default.

4. Carbon Plant

The carbon plant comprises the green anode plant (or paste plant), the anode baking furnace and the rodding shop. The following initiatives can lead to a more sustainable production of anodes for the reduction process:

A very sustainable practice is to use the treated water as irrigation water for grass, plants and trees on the premises. This displaces the use of fresh water and gives the smelter a very clean and natural look. This makes people happy!

More difficult is the water collected in the storm ponds. Because the rain water picks up fluoride from the roofs and equipment it holds a level of fluoride. Normally the water is left to evaporate so that net there is no emission.

There is technology to remove fluoride from water and it may be possible to apply this to storm water ponds. Then the water can possibly be used somewhere else in the plant. Even if this is to flush the toilets!

8. Conclusion

The purpose of the paper is an attempt to refresh everyone's thinking that we can do things different when it comes to the sustainable design of a smelter. In the paper is presented a series of ideas, technologies and practices that can be considered when a smelter is designed or in part upgraded. Each item has a certain sustainability factor to it that – although we don't quantify this in the paper – adds to a higher level of sustainability. It is clear that in every area there are good opportunities to increase the level of sustainability. It is also clear that further research and development is needed to continue to enlarge the sustainability. We hope that some people be inspired with what is possible and start taking some of this into consideration in tier future plans.

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