Smelter Power Modulation in China and Application on High Amperage Reduction Cells

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Abstract

The EnPot system for power modulation of Aluminium smelting cells was developed over many years of research and plant trials at the Light Metals Research Centre. The system uses ducted suction air and patented Shell Heat Exchangers, the airflow through which can be increased or decreased to selectively insulate or cool the pot shell. This allows power modulation of smelters on demand, or for deep modulation operation. This can give great advantages to smelters operating with varying power prices or power availability, which has been seen with increasing regularity around the world. The rapid increase in power price volatility in China and global demand for low-carbon Aluminium has driven demand for modulation, resulting in successful EnPot installation on 6 high amperage cells at a Chinese smelter. Initial results are shown in this paper, demonstrating the potential for both cooling and insulation of large cells, while maintaining operational stability and safety.

Keywords: Power modulation, Demand side response, Heat exchangers, Energy saving, Plant trial.

1. Introduction

The EnPot system was installed in February 2025 at the Binzhou Beihai Huihong New Materials Co. Ltd. Smelter ('Beihai Smelter') on 6 x 440 kA pots. The goals of this trial installation are to prove safety and effectiveness on much larger pots than previously installed, and to gauge the upper and lower operating windows i.e. the power modulation range of operable heat balance. This trial process will necessarily take some time to complete, however data presented in this paper shows the installation and commissioning success, and initial trial results showing safe substantial heat balance changes.

1.1 System for Sidewall Cooling and Insulation

The EnPot system was developed over many years of fundamental and industrial research at the Light Metals Research Centre, University of Auckland, New Zealand. Initially designed to maximise shell heat transfer for large amperage creep, it was further developed to enable potline current modulation both upwards and downwards using the insulating ability of the patented Shell Heat Exchanger (SHE) units [1, 2]. It has been trialled at many smelters of varying design and line current around the world, and is currently in operation on a full potline at Trimet Essen smelter [3]. The installation at Beihai Smelter represents the largest pot it has been installed on,

and very relevant to future industry needs especially in China. A schematic of the system arrangement is shown in Figure 1.

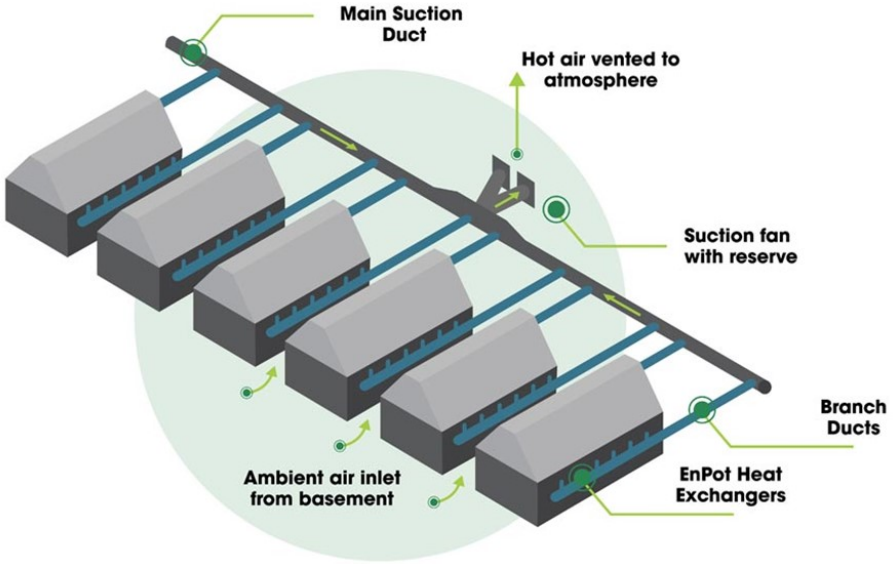

Figure 1. EnPot system schematic diagram.

1.2 Smelter Power Modulation

The ongoing challenges for power supply to Aluminium smelters around the world are now well established, including varying power price and availability over time scales from hourly variations to seasonal or yearly shortages. While the uncertainty of availability and price of power supply is a clear risk for smelters, it can also be seen as an opportunity to take advantage of varying pricing in future, as well as potential for decarbonisation by moving from fossil fuelled power to variable renewable energy, where the smelter provides a highly valuable firming service to the power grid [4, 5].

These challenges exist worldwide, of different complexity and opportunity in every country and for each individual smelter. This is especially true in China, where multiple factors are already at play, with further changes coming in future. These challenges include [2]:

- Government mandates to use more renewable energy in smelting, and to reduce power consumption and emissions [6].
- Changing national capacity caps now allowing for new production or capacity creep at existing smelters [7].
- Regional capacity caps where smelting capacity has been physically moved from coal-fired power regions to those with hydro power.
- Seasonal shortages in hydro power generation affecting capacity caps [8].
- Tiered power pricing based on energy efficiency (DC kWh/kg Al) [9].
- Daily variable power pricing being introduced based on renewable availability.
- Introduction of carbon emission taxes and trading schemes e.g. EU's Carbon Border Adjustment Mechanism (CBAM) [10]

Multiple pricing challenges can now be faced by any one smelter, giving new stimulus in the industry to look to flexible production, as well as other possible benefits such as decarbonisation or even enabling pots to run with lower energy use, as well as capacity creep in some areas where production caps and licences are now in excess. This has directly led to the installation of the first EnPot system in China at Beihai Smelter.

5. Conclusions and Further Work

The key outcome is the successful demonstration of safe operation at significantly increased heat generation using EnPot sidewall cooling. The important information gathered is the slow response time of large 440 kA pots. These tests imposed a one-time large magnitude change in heat generation, with attendant process control challenges. In a situation where long-term amperage creep is the goal, or seasonal power modulations, this can be more easily achieved by a slow ramp of power change to ease process disturbance. The ability for short-term modulation e.g. for hourly power price changes needs further study on process control and stability, as the pot will often be in a transient thermal state which must be managed carefully.

A complete demonstration of potline modulation using EnPot will require a booster group installation, or extension to a full potline in future, in order to test the effects of increased current density on any particular cell design, and to identify other smelter limitations. The thermal balance appears achievable however at +10–15 % power consumption with the system as designed, or may be extended further using end wall SHE units for higher heat dissipation needs.

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