Findings from Operating a Pot with Heat Recovery System

Amal AlJasmi[1] and Abdalla Alzarooni[2]
1. Lead Engineer, Modeling,
2. Vice President, Technology Development and Transfer
Emirates Global Aluminium, Dubai, U.A.E.
Corresponding author: amaljasmi@ega.ae

Abstract

A heat recovery system, HRS, was installed in one pot at Emirates Global Aluminium's Jebel Ali site, to evaluate the potential for energy recovery from the cell as well as the impact of this system on pot operation. The pot is extensively instrumented to allow analysis and monitoring of all related parameters. The impact is two directional: the pot impacts HRS and what happens in the pot impacts energy collected by HRS. The pot operation is impacted by HRS as it influences the cell heat losses and its thermal balance. This can be seen from the shell temperature, bath temperature and excess AlF3 variation. The HRS was also used to reduce the heat losses from the pot during a planned power reduction. The HRS is also impacted by the events that take place in the pot such as the removal of an anode with spike and changes in bath temperature. The paper summarizes these key findings and shows the potential of optimizing the pot performance with HRS.

Keywords: Heat recovery; pot shell sidewall heat recovery; thermal balance.

1. Introduction

Aluminium smelting is an energy intensive process with half of the energy required in the cells lost as heat. This raises interest in the possibility of recovering this wasted heat. The studies in this subject have come a long way: from theoretical calculations and lab testing to full scale trials and industrial potline application. The areas with highest heat losses from the cell are the cell off-gases and the pot shell sidewalls and thus, these these two areas are the main target for heat recovery.

Most of the efforts to recover energy from aluminium pots focus on off-gas cooling. Many reasons made the off-gas energy collection attractive, including the positive impact on gas treatment plants when the off-gas is at lower temperature and thus reducing the volume of gas going for treatment. [1] Also, the recovery from the gas duct does not interfere with pot operation which means installing such a system does not disturb normal pot operations. Off-gas cooling has been tested on industrial scale in many smelters and is planned to go for a full potline installation in Potline 4 in Alba [2].

Recovering heat from the pot shell sidewall has not been as popular. Concerns include the impact on pot heat losses and thermal balance and as a result pot operation and production. However, sidewalls have potential for higher energy recovery rates compared to the off-gas ducts [3]. In addition to the recovered heat, having an external mechanism to turn up or down the heat losses from the sidewall makes power modulation possible on a wider range of amperage [4]. It also means potential for amperage increase with the same pot lining design for smelters that do not use power modulation.

In EGA, as a part of the company strategy to reduce energy consumption, a heat recovery system was installed in one of the pots in the Eagle section where DX+ Ultra cells were commissioned in 2014. The section has five pots and the middle pot was chosen for heat recovery installation. These pots are monitored and followed closely which gives the benefit of availability of measurement and data for comparison when it comes to evaluating the impact of the heat recovery system (HRS). The initial findings from this HRS trial at EGA were published in 2015 [3]. The aim of this paper is to show some of the findings from operating a pot with heat recovery including how it impacted the pot and how in turn the pot impacted some of the parameters in the HRS.

2. Method

The HRS is based on heat pipe technology and was designed by Goodtech Recovery Technologies, a Norwegian company specialized in heat pipe technology for heat recovery applications. The team working on heat recovery from aluminium cells worked on improving the system from the experience in EGA and started Cronus Technology AS. The HRS system consists of two parts: off-gases energy collector (GOC) and pot shell sidewall energy collector (GEC). GECs were installed on the side wall along the length of the pot only, keeping the tap and duct ends design unchanged from normal pots. The HRS is instrumented to be able to monitor all the relevant parameters through a dedicated HMI including temperature of each unit, oil inlet and outlet temperature and oil flow rate.

During the design stage of HRS, ANSYS thermoelectric model was developed with a simplified representation of HRS on the sidewall. This model allowed prediction of cell thermal balance with different energy collection rates from the sidewall. The model also helped with the prediction of the impact on shell temperature and expected freeze. These calculations were later validated with measured values and found to be in good agreement. While some parameters were calculated, other remained unpredictable until we started the pot operation such as required oil flow rate for a given energy collection rate. The focus in this paper will be on the pot shell sidewall energy collector and how it impacts the pot. The term 'HRS' will be used to indicate heat recovery from pot shell sidewall and 'normal' pot will refer to pot without HRS.

3. Findings

One of the findings is the range of heat recovery that was observed from the installed system. Also, in terms of the influence of HRS on the pot, impact on shell temperature, bath temperature, excess AlF_3 and freeze thickness are discussed. Additionally, the impact of bath temperature and formation of spikes on the energy recovered by HRS are also shown.

3.1. Energy Collected

The energy collection rate from the pot shell sidewall was varied using the oil flow rate which was one of the input parameters in the HRS. The maximum oil flow rate was used during start-up (after bath-up) to reduce shell temperature and allow faster freeze formation. The energy collection rate from the sidewall at this stage was 200 kW. This rate was dropped to 100-120 kW during normal operation. There was no requirement to change the oil flow rate and adjust the energy collection from the HRS except during power outage.

3.2. Shell Temperature

Shell temperature is directly impacted by the HRS. The energy collection panels are placed between cradles above the cathode level up to the bottom of deck plate. The heat pipe technology used in these energy collectors has high thermal conductivity in the vertical direction resulting in almost uniform temperature along the block [5]. Thermocouples placed on the shell at the metal bath interface level were used to monitor and compare shell temperature in the pot with HRS and pots without HRS. Figure 1 shows the shell temperature after pouring

5. Practical Aspects

The main aspect is on maintenance. The HRS energy collection units were not replaced since installation. However, many thermocouples on these units needed replacement. These thermocouples might be unnecessary for industrial applications. Also, a cooling system needs to be in place for shutdown of HRS as these units are expected to heat up to about 400°C while the oil in the HRS should be kept below 320°C to avoid any changes in properties. A permanent cooling system was installed to allow easy on and off usage of cooling in case of emergency shutdown of HRS.

6. Conclusions

Heat recovery is believed to impact the thermal balance of the pot. The appropriate settings of this particular HRS allowed similar behavior in this pot compared to pots without HRS. One of the benefits of HRS is the possibility of faster formation of freeze during start-up. The additional energy used to cool down during this period indicates the possibility of amperage increase as more heat can be removed from the pot with HRS. Also, it seems that HRS allows better control of bath temperature and excess AlF_3. The pot response during a power outage shows possibility of insulating the pot with HRS. It is believed that HRS did not affect the other main key performance indicators in the pot while being able to collect about 100 - 120 kW of power from the shell sidewalls.

In summary, the pot performance with HRS was not very different than the performance of normal pots, but with a few additional features it had faster response to thermal imbalance in the pot. It appears that the HRS would be able to operate at higher amperage and it would better tolerate power modulation. The energy collected, if it could be used, could be subtracted from the specific energy consumption of the pot.

7. References

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