Application of Shell Heat Exchanger Supplied with Compressed Air for Pot Sidewall Cooling

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Abstract

Heat removal from the cell in aluminium smelter is essential for temperature controlling. Sidewall cooling helps the formation of side ledge inside the cell. Many aluminium smelters including PT Inalum are currently using compressed air direct cooling to the sidewall of the pot. These air jets inefficiently cool the sidewall as the cooling pattern is non-uniform and the limited air to pot shell retention time eventually requires more compressed air to be utilized. On the other hand, compressed air is needed for other daily operational works so the pressure has to be kept as the requirement. Therefore, Shell Heat Exchanger (SHE) with air supply is introduced for sidewall pot cooling. This technology increases the pot cooling efficiency and eventually reduces the compressed air needed for cooling. Experiment results at PT Inalum showed approximately 15 % compressed air saving by using SHE compared to direct cooling.

Keywords: Sidewall cooling, Shell Heat Exchanger (SHE), Compressed air.

1. Introduction

The shell sidewall temperature of aluminium cell tends to increase overtime during the operational life of the aluminium electrolysis pot, because the capacity creep normally applied in smelters. Heat transferred from the liquid electrolyte through frozen ledge is approximately equal to the heat flow through the sidewall lining from frozen ledge to the steel shell. This heat produced inside the pot eventually cause the ledge erosion. Besides that, capacity creep in smelting cell by increasing the amperage of existing cells also contributes to the sidewall ledge erosion. It has been reported that ledge thickness has decreased from 15–20 cm to 1–3 cm when pot amperage increased from 186 kA to 210 kA for a particular cell design [1]. This is due to the greater heat flow through the cell walls. Stable ledge needs to be maintained for adequate life of the sidewall materials. The ledge erosion will lead to the increasing of pot steel shell temperature.

This steel shell has its maximum tolerance of the heat based on the material resistance. Shell temperatures in excess of 500 ˚C have been measured in the last decades in aluminium smelter worldwide [2]. The temperature higher than pot shell material resistance will eventually cause the pot leakage and the pot has to be cut out. Therefore, the high sidewall temperature needs to be cooled externally to prevent the pot from leakage during operation. Traditionally, sidewall cooling is implemented by direct cooling using compressed air through tubing hose to cool the sidewall hotspot locally. Compressed air increases the convective heat transfer coefficient between ambient air and the shell exterior thus permitting rapid cooling of the shell. However, there are some constraints regarding this cooling method:

a) Direct cooling using tubing hose supplied with compressed air increase the dust aeration and dispersion within the potroom due to unconfined air flow. This issue leads to health hazard which cause respiratory diseases and eye injuries for the worker in the aluminium reduction potroom [3].

b) Less contact time between the compressed air and pot shell being cooled due to the unconfined air flow to the ambient.
c) Not amendable to waste heat recovery in the future because the heated air from the cooling process is not captured [4].

2. Heat Exchanger Concept

Shell Heat Exchanger (SHE) was introduced to overcome the constraints of traditional direct cooling method. This technology has several advantages such as: the ease of installation because it is installed on-line at the inter-cradle space of the pot, localized compressed air contact with the shell side hot spot and increasing the contact time between cool air and the hot spot which eventually lowers the compressed air consumption. Figure 1 demonstrates the operation of SHE for cell sidewall cooling. The air is introduced into the exchanger in such way that additional ambient air is entrained. The air flows up the gap between the steel shell and the SHE and then exits through the top part of the exchanger. The cell wall is cooled while the exchanger outlet air is heated.

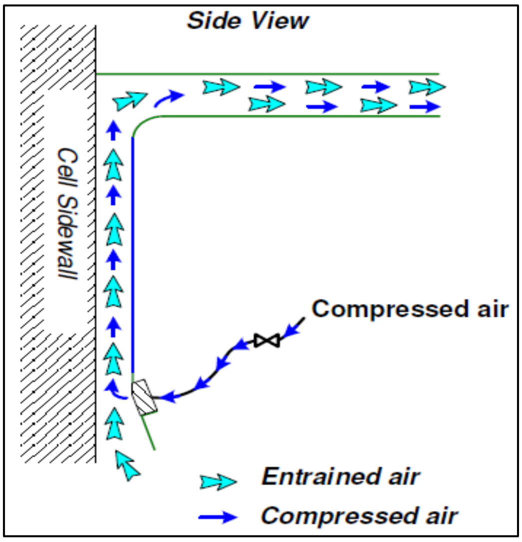

Figure 1. SHE supplied with compressed air working principle [3].

3. Heat Exchanger Prototype Installation

A prototype of Shell Heat Exchanger (SHE) with 20 cm width and 18 cm length was designed and fabricated in the PT Inalum workshop. The dimension of SHE was determined by on-site measurement of the PT Inalum pot sidewall. The pot sidewall dimension difference caused SHE dimensions to be variable. Material used for SHE is aluminium due to its low density (2 710 kg/m^3) compared to other common materials such as steel (7 850 kg/m^3) or copper (8 940 kg/m^3). This low density brings advantage for the manual installation of SHE at the pot sidewall. Besides, aluminium also provides high thermal conductivity (237 W/m·K) which increases the heat transfer in the system to be more effective. The prototype was then installed online at a PT Inalum operating pot sidewall.

SHE prototype was installed on the corner sidewall of the pot (sidewall 1–4, 13–16, 17–20, 29–32). The pot sidewall numbering configuration at PT Inalum is demonstrated in the Figure 2. Typically, corner sidewall has a higher chance to be overheated and be cooled by air injection. It is caused by the metal pad movement due to magnetohydrodynamic (MHD) flow of the electrolyte in the pot which tends to attack the corner side ledge which resulted in high

The utilization of Shell Heat Exchanger (SHE) for normal operating aluminium reduction pot brings several advantages such as the decrease of dust aeration and dispersion within the potroom, ease of installation on the inter-cradle of pot sidewall, energy saving due to lower compressed air needed for the sidewall cooling and also includes the potential to utilize the waste heat for recovery. However, there is also a constraint in the SHE utilization. Visual checking on the pot sidewall is impossible to be conducted due to the SHE coverage of the surface of the sidewall. In this situation, the temperature of the sidewall around the area covered by the SHE still can be considered as a reference.

6. Conclusions

Shell Heat Exchanger (SHE) supplied with compressed air is a promising way to conduct the reduction pot sidewall cooling compared to the traditional direct cooling method. SHE cooling method could potentially reduce 15 % of the compressed air usage compared to direct cooling method. In addition, this improvement also results in the spared compressed air availability to be allocated for other important operational uses in the aluminium production plant. Shell heat exchanger also has advantage on its ease of installation on the sidewall of the pot. Other dimensions of Shell Heat Exchanger (SHE) should be tried to evaluate the effect in its efficiency.

7. References

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