Introducing Forced Convection Network in AP Potlines in Aluminium Bahrain (Alba)

Abdulla Habib[1], Nabeel Al Jallabi[2], Hassan Almohri[3], Mohamed Edrabooh[4] and Abhijit Dhokate[5]
1. Chief Operations Officer
2. Senior Manager Process Control
3. Senior Superintendent Process Control
4. Process Control engineer
5. Senior Mechanical Engineer Infrastructure & Engineering

Aluminium Bahrain B.S.C, Manama, Kingdom of Bahrain
Corresponding author: hassan.almohri@alba.com.bh

Abstract

This paper presents the successful implementation of a Forced Convection Network (FCN) project in the AP30 potlines at Aluminum Bahrain B.S.C. (Alba), the world's largest aluminum smelter ex-China. As part of a continuous program of expansion and technology upgrades, Alba has implemented various strategies to increase the line current while maintaining the pots thermal balance. The FCN project involved introducing a network of ducts around the four sides of the pots to provide forced air convection around the pot shell. The success of the project was validated based on airflow measurements which enabled an amperage increase of 11 kA in both AP30 Lines 4 and 5. This paper outlines the approach developed, project execution, and the results achieved after introducing the FCN.

Keywords: Forced convection network, Current increase, Thermal balance, AP technology.

1. Introduction

Aluminum Bahrain B.S.C. (Alba), established in 1971 as the first aluminum smelter in the Middle East, is now consisting of 6 reduction potlines producing over 1.6 Mtpa. Alba started Line 4 with 288 reduction pots as its first potline with AP30 technology in 1992 followed by Line 5 - the longest potline at the time - with the same technology consisting of 336 reduction pots in 2005. Alba has successfully increased the current in both potlines to 400 kA by 2021 without the implementation of FCN as a result of a chain of current increases through the years. Introducing cutting edge technology has enabled Alba to increase current while maintaining good current efficiency which is considered as a benchmark among all AP30 potlines around the world [1].

As the journey continues, Alba's ambition to increase current beyond 400 kA found the necessity to implement FCN to its two AP30 potlines consisting of 624 reduction pots. The design of this system comprises of two main networks: the pot duct networks (PDN) for each pot; and the Air Distribution Network (ADN) comprises of 4 main headers, with each header connected to the pots shells of a specific potline set, and 6 fans connected to each main header, installed at almost equal distance. Proper implementation of FCN requires a combination of concept design, successful installation, and an efficient start-up strategy.

2. Technical Background

One of the most important constraints in aluminum production using the Hall-Héroult process is to maintain the thermal balance of reduction pots in order to achieve optimum operational conditions, current efficiency and the best technical and economic benefits. The thermal balance of the reduction pot has been achieved by adjusting process parameters and implementing design modifications. However, such strategies have proven to have their limitations at higher stages of current increase. The main objective of the FCN is to dissipate the excess heat generated by higher current while maintaining process key performance indicators (KPI's) and most important, current efficiency at a good level. In 2001, Aluminum Pechiney; a global leader in aluminum technology patented the FCN [2] with the intention of introducing a technology to cool down the pot side shell temperature and provide reliable protection for reduction pots to operate at higher current. Modelling tools, such as a computational fluid dynamic (CFD), a finite-element thermo-electric model, pressure loss calculations and other design tools were used by Pechiney to obtain the optimum FCN design [3].

Pot shells are typically protected by a frozen layer of cryolite, called ledge profile, formed naturally due to the temperature gradient inside the pot. The FCN works through a series of nozzles connected around the pot shell providing localized air blown, ideally at the bath-metal interface which is considered the weakest point of the ledge profile inside the pot shell. By applying the FCN, Alba managed to increase current by 11 kA in both Line 4 and Line 5 without the need to squeeze the anode-cathode distance (ACD). One of the main advantages of the FCN is to improve the robustness in operating potlines.

3. Preparation and Installation

A team consisting of Alba process control, engineering and operation was formed to implement the FCN. To properly plan and validate the FCN effect, several measurements were taken prior to current increase and FCN start up:

- Pot shell temperature measurements,
- Ledge profile measurements,
- Superheat measurements,
- Metal inventory,
- Collector bar temperature,
- Clad temperature,
- Total anode voltage drop,
- External voltage drop.

Prior to current increase, FCN was tested - air velocity measurements and static pressure measurements were taken at different damper openings from the PDN and at different number of operating fans to assess the fans performance. Moreover, the same measurements were taken from the nozzle outlet. The air velocity measurements at this stage were useful and were employed at later stages to find the interpolated value between fan damper opening and air velocity, to determine the FCN setting required at the desired air flow (see Figure 1).

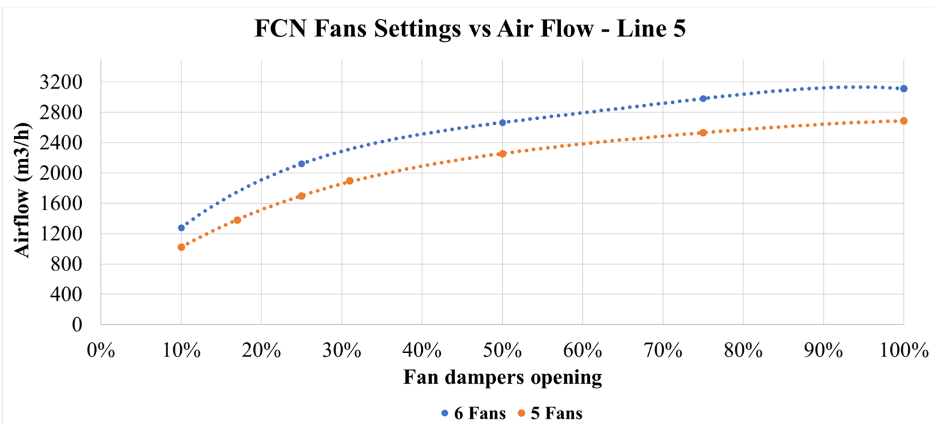

Figure 1. FCN fan damper opening vs air flow on polynomial trendline.

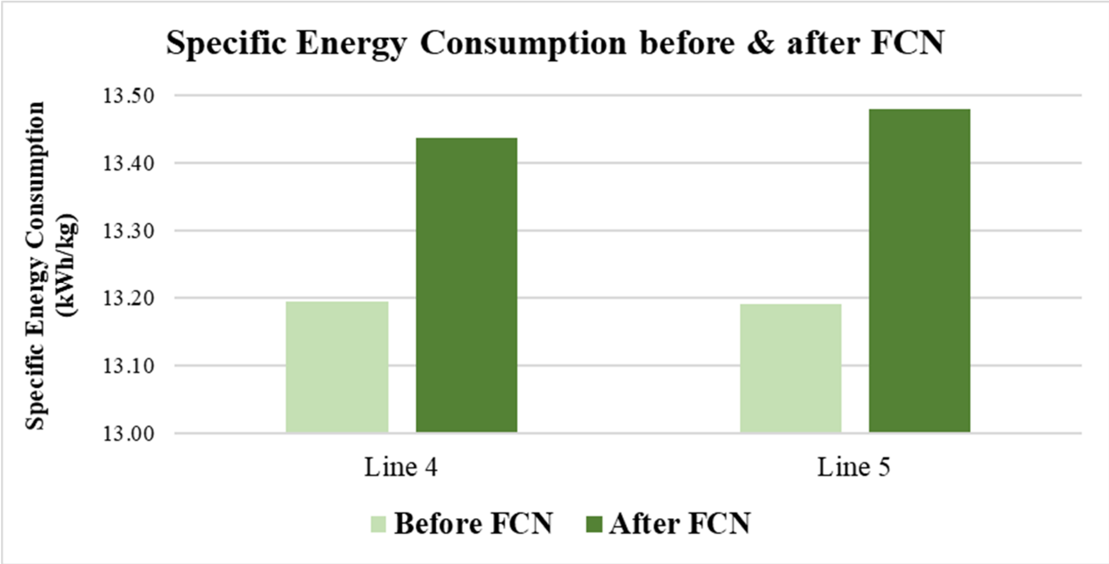

Figure. 11 Alba specific energy consumption before & after FCN.

5. Conclusion

Alba has successfully and safely implemented FCN in both of its AP30 potlines taking into consideration concept design, successful installation, and an efficient start-up strategy. As a result, potline operational conditions were improved, better protection of the side shell was gained, and high current efficiency was achieved.

6. References

1. Mohsen Ahmed Shukralla, Ebrahim Hassan Qasim, Hassan Almohri, Vasantha Kumar Rangasamy, Mohamed Edrabooh and Dr. Abdulla Habib, The roadmap of AP-Alba to 400 kA, *Proceedings of 39th International ICSOBA Conference, Virtual Conference,* 22-24 November 2021, *TRAVAUX* 50, 625-635.
2. Jerome Bos, Benoit Feve, and Pierre Homsi, Electrolytic pot for production of aluminum using the Hall-Héroult process comprising cooling means, *US Patent* 6,251,237, filed Nov. 18, 1999, granted Jun. 26, 2001.
3. S. Guérard, Modelling and Design of a Forced Convection Network for Hall-Héroult Cells, *Proceedings of the 34th International ICSOBA Conference*, Québec City, Canada, 3-6 October 2016, *TRAVAUX* 45, 571-578.