CFD Simulation of Busbar Tunnels in EGA Jebel Ali Potlines

Russell Hall[1], Olivier Charette[2], Matthew Del Gobbo[3], Wayde Johnson[4] and Ghalib Al Falasi[5]
1. Mechanical Engineer - Oil and Gas, Hatch Associates Ltd., Dorking, United Kingdom
2. Engineering Manager - Aluminum, Hatch Associates Pty Ltd., Abu Dhabi, United Arab Emirates
3. CFD Analyst - Technologies
4. CFD Engineer - Technologies
Hatch Associates Ltd., Mississauga, Canada
5. Senior Manager Potlines - Midstream, Emirates Global Aluminium, Abu Dhabi, United Arab Emirates
Corresponding author: russell.hall@hatch.com

Abstract

A recent project undertaken by EGA to investigate the busbar ventilation tunnel system for all Jebel Ali potlines is discussed. The purpose of the study was to perform Computational Fluid Dynamics (CFD) modelling to support findings from an ongoing site investigation of all busbar ventilation tunnels and optimize the ventilation configuration. Busbar temperature criteria were developed based on maximum continuous operating temperature of busbar insulation grouting materials and a volume-averaged temperature was used to reduce overall energy wastage. The modelling incorporated all heat transfer mechanisms – conduction, convection and radiation, fluid flow and turbulence within the ventilation tunnels, and Joule heating within the busbars. Ventilation fan performance curves, louvre openings, and gratings were incorporated to accurately predict the overall system behavior. A site measurement campaign was undertaken to validate and compare the CFD model results to temperature and flow rate measurements, with good agreement obtained. Various illustrative results are presented to demonstrate the use of CFD combined with site measurements as a useful tool to understand and optimize complex ventilation systems. Specific performance improvements to the ventilation systems as a result of the study included installation of additional fans, baffles to improve heat transfer, and walls to segregate ventilation zones.

Keywords: Computational Fluid Dynamics, Busbar ventilation in tunnels, Heat transfer from busbars, Industrial cooling fans, Fan curves.

1. Introduction

Emirates Global Aluminum (EGA) operates seven potlines at Jebel Ali. The smelter operations started in 1979 and went through various expansion and retrofit phases. The site now encompasses 1 577 cells using six different reduction technologies operating at currents ranging from 240 kA to 500 kA. A unique feature of the site is that the reduction cell groups are connected via underground busbars, to keep the smelter operating floor at the same elevation as the roads. The busbars are routed through concrete tunnels which include supports and electrical insulation positioned between the aluminium busbars and the supports. Fans connected to the tunnels provide forced ventilation cooling for the busbars while hot air is vented at specific louvred openings or allowed to exit at potline connections via installed gratings. Typical features of a busbar ventilation tunnel system for Potline 7 are highlighted in Figure 1. This tunnel system is quite complex because it interconnects three out of four potrooms of the potline. Potline 9 busbar tunnel system, shown in Section 5.3, is even more, exceptionally complex since it interconnects 10 short potrooms, built in this way because of limited space in the smelter.

EGA has recently experienced busbar overheating issues particularly within the Eagle section at Jebel Ali Potline 5 [1]. Excessive busbar temperatures can severely damage the electrical insulation between the busbar and the concrete support. The thermal expansion associated can cause unwanted displacement which can impact the busbar heat transfer and increase mechanical stresses in weak components such as welded joints. Damaged electrical insulation and excessive busbar displacement represent a risk for the potline stability.

A scope of work to examine the ventilation systems for all busbar tunnels on the plant was undertaken by Hatch. Computational Fluid Dynamics (CFD) modelling was used to assess the existing ventilation performance and recommend options for ventilation improvement if required based on busbar temperature limit criteria.

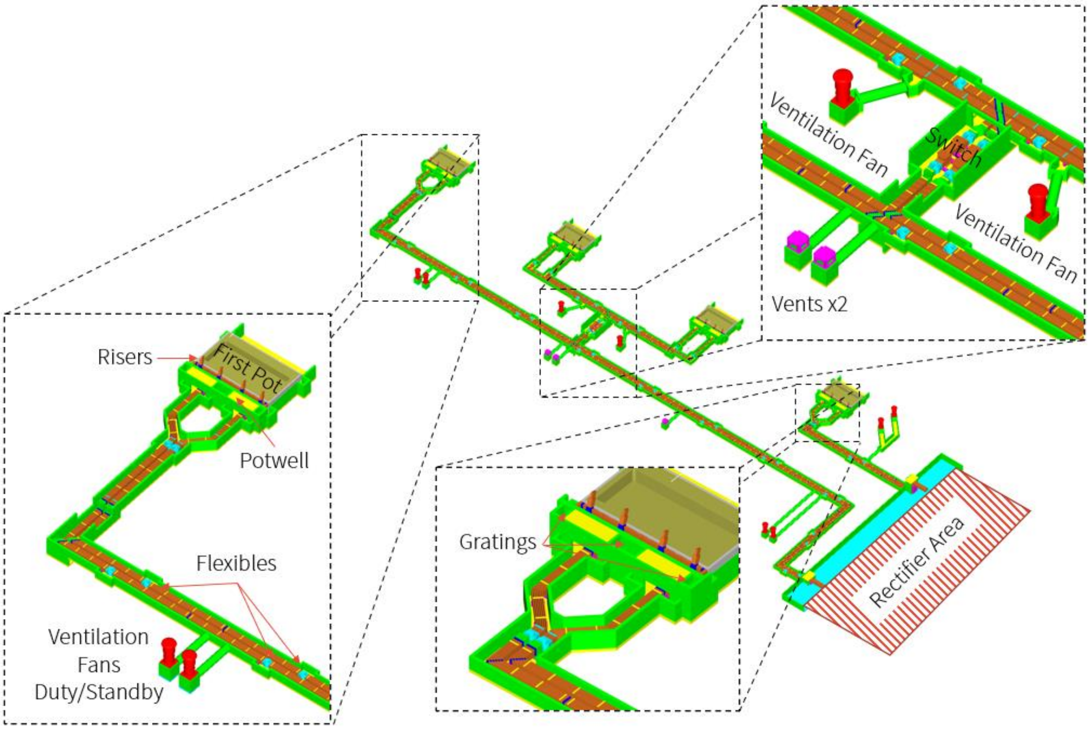

Figure 1. Potline 7 3D model highlighting typical busbar ventilation tunnel components (tunnel concrete covers not shown for clarity).

The objectives of the study were as follows:

1. Predict busbar temperature, air flow distribution, air temperature, and pressure drop in the tunnel networks.
2. Use the information gained from these initial models to optimize the air flow within the tunnel system in order to minimize busbar temperatures to acceptable limits considering future current creep. Measures available included: adding fans where required, additional outlets (including ventilation grills), baffles to improve heat transfer in local regions or practical tunnel modifications at suitable locations.

2. Evaluation Criteria

Following discussion with EGA personnel and EGA's consultant, Dr. Vinko Potocnik, the agreed upon criteria for busbar temperature were as follows:

- Volume averaged busbar temperature limit of 100 °C.
- Local maximum busbar temperature limit of 150 °C.

- Following the CFD modelling outcomes on the project, further engineering scope to implement ventilation configuration changes is ongoing on other potlines.
- Implementation of CFD modelling recommendations will assure adequate busbar cooling in all tunnels and safe operation of the potlines at planned future amperages.

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8. References

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