Electroslag Welding (ESW) -
A New Option for Welding Aluminum Bus Bars in Smelters

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Abstract

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In recent years, a new welding process for aluminum bus bars, Electroslag Welding (ESW), has been developed, tested and used industrially, permitting significant productivity gains both in time and manpower. ESW offers among other advantages the possibility to modify or repair bus bars of an operating smelter with minimum power shutdown time (about 20 minutes per full bus bar cross-section weld) and to build a new rectifier room reducing the construction time and the costs by more than 50 %. The present paper will describe this new welding process and its optimization, discuss the weld quality and present a few industrial applications, such as factory construction of the bus bar network of a new smelter by assembly of sub-modules and the alteration of the bus bar network of a smelter in operation in order to add a new rectifier to the network for additional production capacity.

Keywords: Electroslag welding (ESW); aluminum bus bar welding; busbar sub-assembly; aluminum smelter capacity creep.

1. Introduction

When it comes to join two very thick metal plates, Electroslag Welding (ESW) is the most productive, single pass welding process available. Developed simultaneously in the 1940's in the United States by Kellog Co. and in the Ukraine by the Paton Institute, the ESW was used extensively with steel in the 1960's for railroad tracks, bridge beams, ship hulls, traction motor frames, etc.

In the meantime, the traditional method used by the aluminum industry to weld heavy aluminum bus bars was « staggered plate » method (Figure 1). With this approach, plates about 12 mm thick are piled in a staggered pattern one by one. Gas Metal Arc Welding (GMAW) is then done on each edge. The process is then repeated until the joint between the two bus bars is entirely filled.

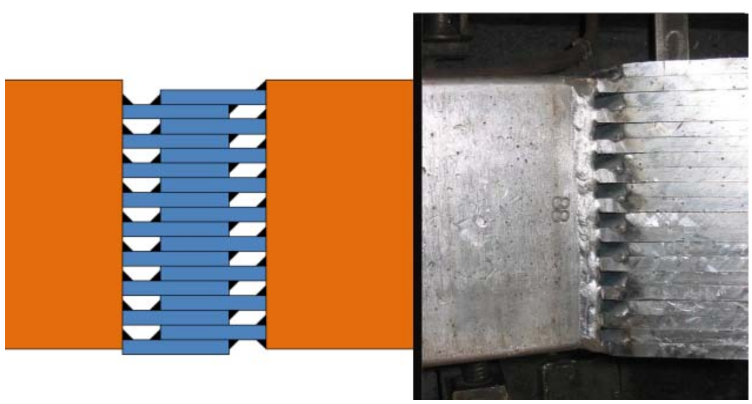

Figure 1. Staggered plate method for bus bar welding.

However, the resulting weldment has typically only about 80 % of full cross-section electrical conductance due to gaps that are left and weld quality issues; it is also very time-consuming and, in the case of a Greenfield plant, requires a great deal of competent workforce at the same time.

Trying to overcome those irritants, CANMEC developed the ESW for aluminum between 2003 and 2006, starting from the work achieved in the 1970's by the Union Carbide Company (UCC) through its subsidiary Linde.

A five head unit finally provided the ideal combination of electrode spacing. The Alcoa Fjarðaál Aluminum Smelter Iceland project [1] was then the ideal platform to test the new technology with the result that the bus bars were welded in two weeks only, compared to two months if the traditional method had been used. The welded area and the ESW provided better quality welded joints while reducing the welding time in total man hours per welded joint by half.

2. Principle of Operation

The principle of operation of the ESW process is shown in Figure 2. In summary, this process is initiated by an electric arc that is struck between a wire, fed into the location to weld and two slightly spaced vertical plates. A powdered flux is then added and it melts to form the slag that will shield the weld pool. Through a consumable guide that extends down the length of the joint, the wire is continually fed into the surfaces of the metal workpieces. With this method, the welding head remains at the top of the joint, while both the electrode and the guide tube are progressively melted by the slag. A retaining shoe, put into place before starting the process, is used to keep the coalesced metal between the plates. The result is a single pass welding joint obtained much more rapidly than with the conventional method (Fig. 2).

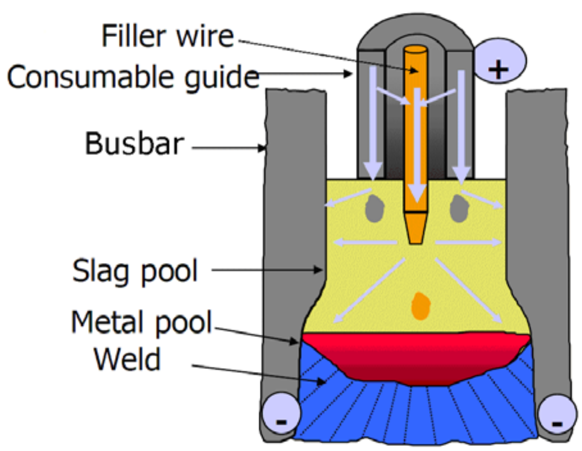

Figure 2. Sketch of Electroslag Welding process.

3. Process Description

The bus bars to weld are typically made from the 1 000 alloy series, and more specifically from 1350 or 1370 alloy. The main steps for the process are: the preparation of the joint, the bus bar assembly, the welding and the finishing.

3.1. Preparation of the joint

To ensure that the spacing between the bus bars will be maintained along all the length of the weld joint, it is important that the edges of the bus bars are cut at right angle and that the surface

The magnetic field in the working area was 110 mT (millitesla). The welding had then to be performed through 6 operation shutdowns, each one being one hour long. It combined ESW and Gas Metal Arc Welding (GMAW) to achieve the results expected.

Connections to the existing network required adapted design (see Figures 22 and 23). In this case, an interlinked connection to 6 previously independent conductors proved necessary to distribute the 100 kA load.

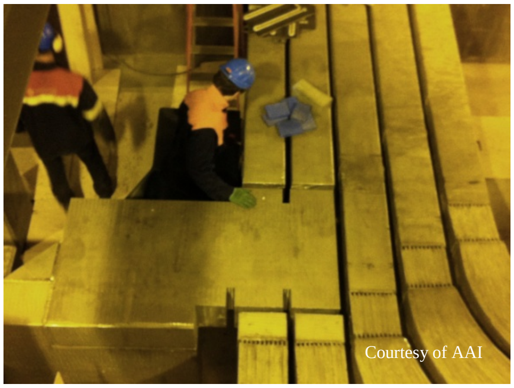

Figure 22. Interlinked connections used in Iceland.

Figure 23. Interlinked connections used in Sept-Îles.

In conclusion, this new way to proceed allows no compromise on interconnectivity, no overheating due to uneven current distribution, as well as an optimum quality of connection. It also permits very often to add extra staggered plates since the manual welding time allows it during a plant shutdown.

7. Conclusions

The Electroslag welding is an innovative method to join aluminum bus bars that allows significant gains both in manpower and time. It also makes possible the modification of the bus bar circuit while in production, a task that was impossible using the staggered plates welding method.

In summary, ESW shortens bus bar installation, improves electrical conductance of the joint to reduce the welded joint voltage drop by 22 %, provides welding joint of very high quality, and represent a significant gain of time (20 minutes for a standard joint).

CANMEC is now working on the Electroslag Welding in the presence of strong magnetic fields in order to save more power shutdown time during busbar modifications in an operating plant.

8. References

1. Bechtel, Fjarðaál Aluminum Smelter Iceland (2004 - 2007), online at http://www.bechtel.com/fjardaal_aluminum_smelter.html.
2. Pictures, 13, 14 and 17 are a courtesy of RTA Kitimat.
3. Pictures, 18, 20, 21, 22 and 23 are a courtesy of Aluminerie Alouette Inc.