TriOx Combustion System Provides Low Dross Formation
In Side Well Aluminum Melting Furnace

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The reduction of aluminum oxide or dross losses represents a significant material and cost savings opportunity to the secondary aluminum melting industry. Many secondary melting furnaces are of the reverbatory and side-well charged type and employ natural gas fired burners. Throughout the melting and/or holding process furnace atmospheric oxygen is allowed to contact the surface of the melt and aluminum oxide is formed. The aluminum oxide combined with fluxing salts form dross on the surface of the melt, similar to the slag that forms on steel, which acts like a sponge trapping pure aluminum and reducing process yield. Aluminum oxide formation is a complex phenomenon that is largely a function of both bath temperature and oxygen level. Increasing bath temperatures and higher levels of oxygen availability will increase dross formation rates. Thus, there are two essential parameters to control dross formation: fuel-air equivalence ratio and melt temperature. Firing natural gas at stoichiometric ratio would reduce dross formation, but has other implications including CO and VOC emissions. As a result, most melters operate in the 5 to 10% excess air range; however, with conventional burner technology, this typically results in 1 to 2% dross loss.

Hauck Manufacturing Company has developed and patented a new ultra low NOx gas fired burner, named TriOX, which utilizes a unique three-staged air injection design for maximum production efficiency while minimizing dross formation and emissions. A four burner TriOX system was installed on a new 190,000lb side-well charged aluminum melting furnace at Metalico, Inc. in Syracuse, N.Y. in March 2007, Figure 1. The furnace is designed for melting aluminum scrap in the side well while casting from the main furnace chamber in which the burners are fired. Total furnace heat input is approximately 24 MMBtu/hr. A high volumetric flow circulating pump moves molten aluminum from the main chamber through the side well. The furnace is additionally equipped with pressure control to minimize tramp air infiltration and uses cascade temperature control to transfer from roof to bath thermocouple for optimum melting and holding efficiency. At furnace temperatures above 1,600ºF the burners operate in Invisiflame® mode, a patented design feature which when combined with optimum burner placement on the furnace results in diminished oxygen levels near the molten bath surface.

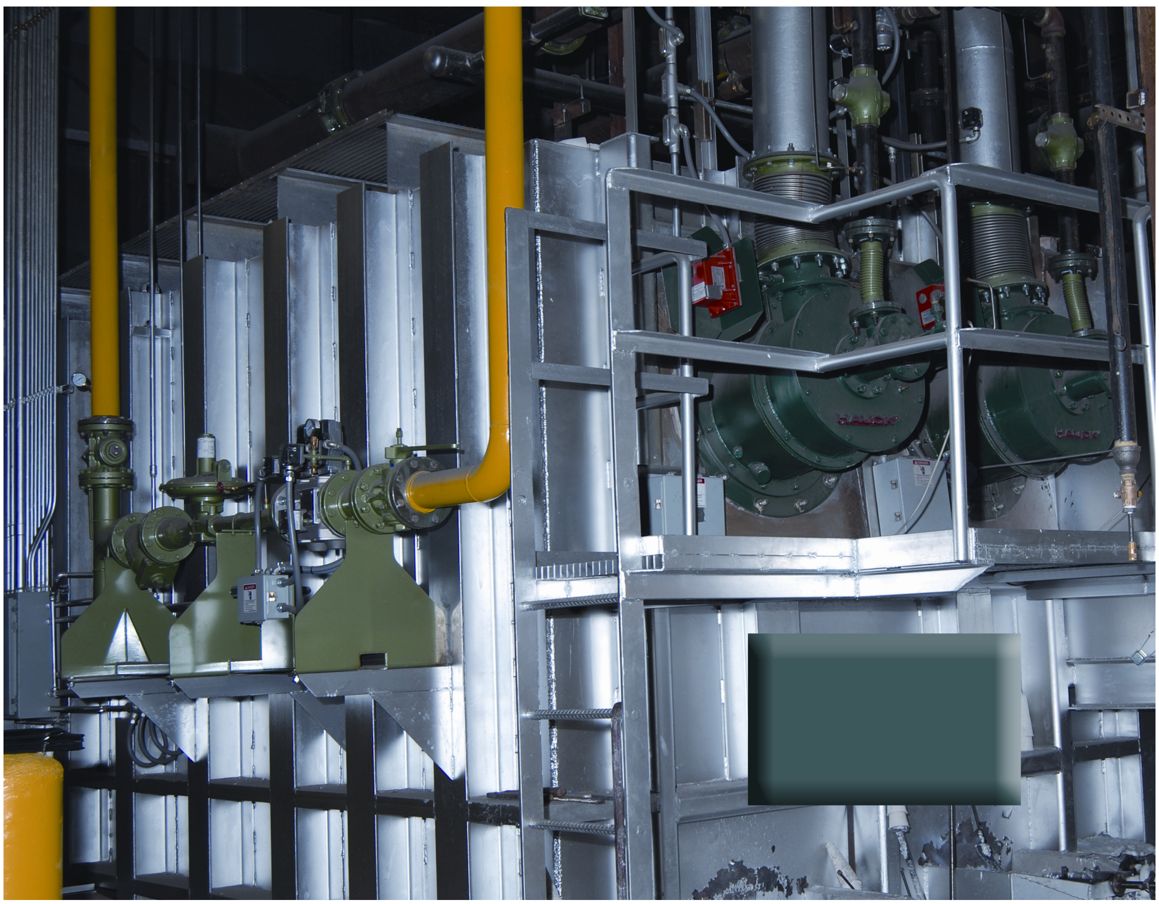

FIGURE 1: Side Well Melter,   Main Chamber and Burners.

A 24 hour test was conducted to fully evaluate metal loss over numerous loading/tapping cycles. Throughout the test the burners were operated in Invisiflame® mode and with approximately 5% excess air. During the test the side well was charged with scrap at the average rate of 10,200 lb/hr. The scrap consisted of sheet bales of building scrap (approximately 30 x 48 x 62in), dried machine turnings and compressed chips called pucks, approximately 3 in. thick by 6 in. in diameter. The side bay was drossed off each time the type of scrap being charged was changed. The main furnace chamber was drossed off only at the end of the test. Fluxing salt was used in the side bay to help remove impurities. The weight of all scrap and fluxing salts used was carefully measured throughout the test. Casting was continuous at an average rate of 9,460 lbs/hr. Final cast product, dross from the side bay which included many impurities found particularly in the sheet bale material, and the final dross removed from the main chamber at test completion were carefully measured. During the test the average bath temperature in the main chamber was 1,442ºF and the average gas temperature in the main chamber was 1,862ºF. The amount of dross that was produced from the main chamber during the test was 970 lbs. This represents a metal loss of 0.4% based on total scrap, 245,000 lbs, charged into the furnace. Compared to the average side well melting furnace using cold air burners producing 1 to 2% dross loss in the main heating chamber, a 0.4% dross loss on the Metalico furnace represents a minimum 2.5 time reduction in metal loss compared to typical furnaces of this design. Conservatively comparing the 0.4% to typical 1% dross losses results in metal savings of approximately 1480 lbs/day at the current production rate. Further assuming furnace utilization is 90% and it has a scrap charge rate of only 70% of its full rate, the melt loss savings would amount to 338,000 lbs of aluminum per year. At $1.20/lb of aluminum, savings of over $400,000 per year are possible resulting in complete combustion system payback of well under 6 months.

The reduction in dross formation is primarily attributed to the low oxygen concentration on the bath surface combined with the Invisiflame™ or distributed flame pattern created in the furnace by the TriOX burners. The burners are installed on the side wall of the furnace and inclined down at an angle of 10º relative to horizontal. Figure 2 shows a Fluent® Computational Fluid Dynamic (CFD) model of the air and natural gas flow profiles exiting the burner. The fuel flow, shown in red, is substantially deflected downward as it exits the burner with far less momentum than the air jets, shown in blue. As a result, the low oxygen concentration region of the flame is directed toward the bath surface, a condition which minimizes oxygen availability at the bath surface to minimize dross formation. In addition, the flame is stretched in the longitudinal direction as air and fuel mixing is intentionally delayed for ultra low nitrogen oxide (NOx) emissions. The stretched flame pattern extends the hot combustion gas region throughout the main firing chamber as opposed to creating localized hot spots, often the case with high momentum burners angled down, which additionally suppresses oxide formation. Note the high circulation rate of the molten metal pump efficiently moved cold metal into the main chamber aiding heat transfer and minimization of dross losses.

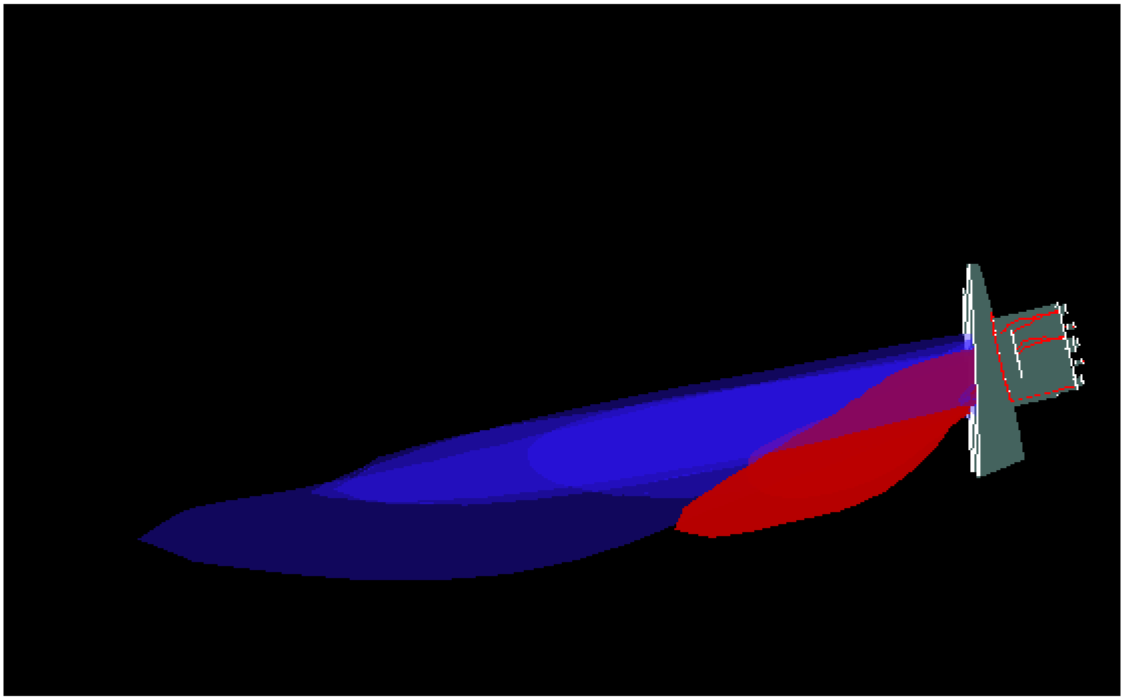

FIGURE 2: Air and Fuel Jet Paths.

The oxygen distribution on the bath surface is shown in Figure 3.

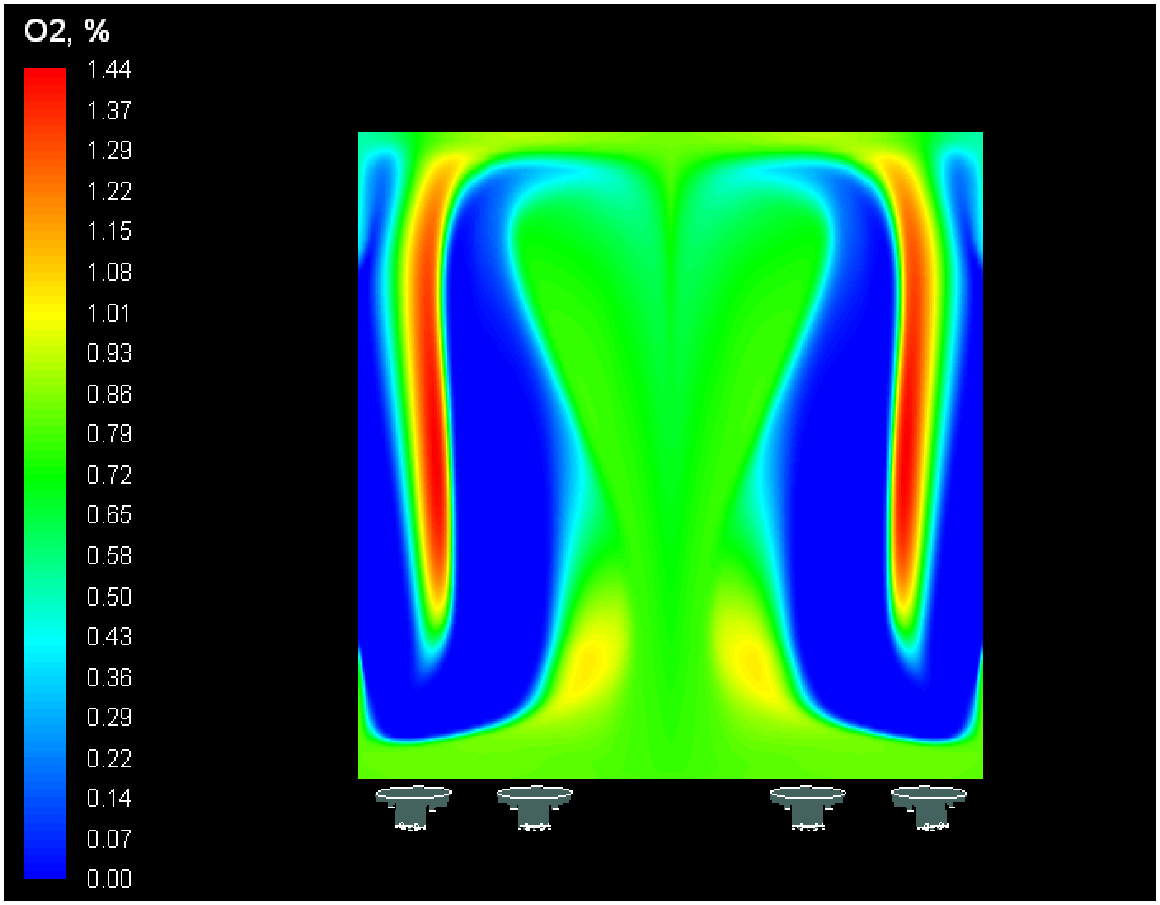

FIGURE 3: Oxygen Volume Concentration On Bath Surface.

Even though the burners are firing at approximately 5% excess air, corresponding to 1% O_2 in exhaust gas, the O2 profile along the bath service on the burner axis is only an average of 0.495% due to the burner air/fuel flow and resulting flame profile.

A novel four burner system resulted in melt loss reductions an order of magnitude less than conventional burner systems on a side well melter successfully demonstrating significantly higher product yield while simultaneously providing ultra low NOx, CO, and VOC emissions. For producers striving to strike a balance between environmental regulations and production output, recent technology advancements in burner design can provide an attractive payback.