Energy-Efficient Melting and Direct Delivery of High Quality Molten Aluminum

Complete Scrap-to-Caster System Will Save Energy and Reduce Costs in the Aluminum Industry

In aluminum foundries, aluminum is melted in natural gas-fired reverberatory furnaces where heat is transferred to the surface of the molten aluminum by refractory radiation and some convection. These furnaces are characterized by poor thermal efficiencies ranging from approximately 20%–45%.

The Energy Efficient Isothermal Melting (ITM) of Aluminum project, currently funded by DOE, developed energy-efficient and emissions-free electric melting furnaces for large-scale aluminum operations. These furnaces use direct immersion electric resistance heaters which yield high thermal efficiency (about 99%) and low melt loss (less than 1%). Unlike conventional gas-fired furnaces, ITM melts aluminum via conduction and convection using a multi-bay, continuous-flow system that features two independent heating sources: The first is an array of high-heat-flux, direct-immersion electric heaters that supply melting heat; the second is a moderate-heat-flux refractory panel heating system that provides holding heat for the molten aluminum.

The ITM project has been extended to further improve the energy efficiency of the furnaces. The extension project will develop a combined system to efficiently melt and deliver molten metal. The system involves preparing and melting the metal off-site using efficient electric Direct Immersion (DI) heaters, then transporting the molten metal in Transportable Electric Ladle (TEL) trucks to casting operations. Docking stations at remote casting operations receive these vessels, allowing them to be drawn down over a period of time and essentially displacing on-site holding furnaces. These smaller, conduction-heated holding vessels operate at less than 10 Btu/hr-lb compared to the 30 to 40 Btu/hr-lb consumed in typical industrial holding furnaces.

The combined system will outsource melting and eliminate large holding furnaces in many production facilities. Melting operations can be centrally located and operated in the most efficient mode, and foundries will receive ready-for-use, treated molten metal at ideal temperature.

A 7,000lb commercial prototype ITM was commissioned for Aleris Rolled Products at their Newport, OH facility. This unit is capable of a 5,000lb/hr output when melting light weight scrap (edge trim), and up to 7,000lb/hr solid charge.

Photo courtesy of Apogee Technology, Incorporated.

Benefits for Our Industry and Our Nation

The integrated delivery and dispensing system further reduces metal loss and contamination, provides the flexibility to change alloy chemistry and eliminates the need for energy-intensive holding furnaces at the casting site. The overall energy savings of the integrated system could exceed 85%, compared with the current practice of conventional melting, gas burner-preheated ladles, and the reliance on insulation and superheated metal which limits transport time and distance.

Other benefits include reduced on-site emissions of carbon dioxide (CO_2), sulfur oxide (SO_x), nitrogen oxide (NO_x), and particulates, as well as reduced dross formation.

Applications in Our Nation's Industry

The commercial applications for the integrated ITM/TEL metal supply system are widespread. In the aluminum industry, both the wrought alloy and engineered castings sectors will have a compelling need for the integrated system. The potential cross-cutting applications for the technology will extend energy savings and environmental benefits beyond the aluminum industry to other metal melting processes such as lead, zinc, magnesium, and copper and for other material melting like glass.

Project Description

The objective of this technology is to eliminate melting and holding furnaces at the casting site by moving these operations to centralized and optimized off-site facilities.

A demonstration will prove the capability of operating a 8,800 lb/hr casting line with ready-to-use molten metal delivered by detainable transport vessels, with a gross energy input less than 650 Btu/lb, using off-site melters and no in-plant holding furnaces.

Barriers

- Developing and demonstrating an integrated system to melt and transport molten aluminum
- Creating a paradigm shift in the industry required for implementing this technology

Pathways

The new process has been showcased at Aleris International's operations and GM's Powertrain Division in Saginaw, Michigan, beginning in 2009. In this new demonstration, melting will take place at Aleris in an Isothermal Melter, and then TEL trucks will transfer and dispense molten aluminum at GM's casting operations site.

The strategies that were used to achieve the project goal included the following:

- Developed electrically-heated vessels to transfer molten metal to casting operations
- Developed docking stations to receive molten metal
- Integrated the technologies with an ITM furnace to form a complete system that improves energy efficiency

Milestones

- Implement stand-alone Direct Immersion (DI) heaters for melting, and Baffle and Side Pocket panel (BSPP) heaters for holding molten aluminum (Completed)
- Implement Conductive Trough (CT) (Completed)
- Design, build, and operate 11,000 lb/hr-sized ITM furnace
- Design, build, and operate TELs and docking stations (Completed)
- Integrate ITM/TEL/CT unit operations to support 8,800 lb/hr casting line

Commercialization

The commercialization strategy consists of developing strong partnerships with high-visibility end users and suppliers. Other components of the commercialization strategy include leveraging customer experiences and testimonials, providing leasing opportunities for melters and ladles, and expanding international sales through third parties.

Project Partners

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DOE/EE-0407 • May 2011
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