Industrial Technologies Program

Clean Steel Casting Production

Gating for large steel castings in bottom-pouring ladle operations make use of ceramic tiles. The current practice is to connect the pouring basin to in-gate(s) by a straight sprue and runner(s) without a choke to maximize the metal flow. Unlike a sand mold, these tiles are impervious to air; hence, the pressure loss at the pouring basin/sprue connection caused by the sudden acceleration of molten metal is not considered to lead to air aspiration. However, air entrainment occurs where the ladle stream impinges on metal in the pouring basin, and in a fast running sprue, most of this air is carried forward into the mold cavity. This entrained air is largely responsible for much of the surface defects, especially those known as the cope-side defects that appear on the top surface of the castings.

Inspired by continuous casting operations, remedies have been sought by SCRATA, UK (now Casting Technology International) and Steel Founders Society of America in the form of isolating the ladle stream using a sleeve or a shroud (non-contact refractory tube with inert gas) to directly pour the steel into a mold cavity. However, these methods have been found to be too difficult to implement by most foundries. In the current project, an intermediary holding vessel, a pouring basin, will be used. Entrained air will be removed from the pouring basin by weir-dam arrangements and a choked sprue design. Alternatively, air entrainment will be prevented completely by implementing a submerged nozzle entry into the pouring basin. This is much smaller than a submerged sleeved/shrouded entry into a casting cavity; therefore, it is easier and less expensive to implement. A flow model will be developed to keep track of the head heights in the ladle, pouring basin and the mold cavity during a pour to ensure all components are sized correctly to prevent over- or under-flowing in the pouring basin.

The anticipated benefits of remedying the cope-side defects is a 50 percent decrease in scrap rate, a 50 percent decrease in finishing operations, and a 50 percent improvement in machinability.

Figure 1: Cope-side defects in plate castings.

Benefits for Our Industry and Our Nation

- *Savings of 290 kWh electricity and 560 cu.ft. natural gas per tonne of steel casting produced*
- *Anticipated energy savings based on an 80 percent penetration of new technology into this segment of production will be 2.0 TBtu/yr*
- *Casting defects related to cope-side cleanliness will be reduced.*

Applications in Our Nation's Industry

The project will optimize the large steel casting process by reducing casting defects, especially those related to cope-side cleanliness. The cleanness benefits of this project will include decrease in scrap rate and improvement in the machinability of steel.

Project Description

The specific objectives of this project in various areas are as follows:

1. Prevention of air entrainment into the mold cavity.
   a. Develop a flow model to keep track of metal head height in the pouring basin as intermediary vessel during pouring.
   b. Conduct water modeling to demonstrate the effect of the existing and proposed pouring methods on entrained air. Use water modeling to improve upon proposed designs to remove entrained air from the pouring basin or to prevent its entry altogether using a submerged nozzle extension. Apparatus to measure entrained air under typical pouring conditions.
   c. Carry out experimental castings with the standard and proposed methods to compare and quantify the defect counts.

2. Reduction of sand/metal reactions. The joint effects of mold filling time, mold coatings and residual deoxidizer will be determined for cope-side defects in experimental castings.

3. Industrial experiments and technology transfer. The recommended gating, molding and melting practices from laboratory results will be implemented by the industry sponsors and monitored as a first step to commercialization.

   The results will be reported at the Casting Congress and published in AFS Transactions.

Milestones

1. Flow model
2. Water modeling
3. Steel castings
4. Macro/micro characterization
5. Reduction of sand/metal reactions
6. Industrial experiments and technology transfer

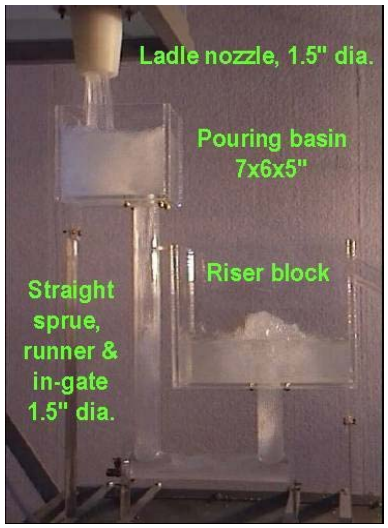

Figure 2 (a): Water modeling showing simulation of a standard ladle bottom-pouring practice that entrains 30-60% air by steel volume into a mold cavity.

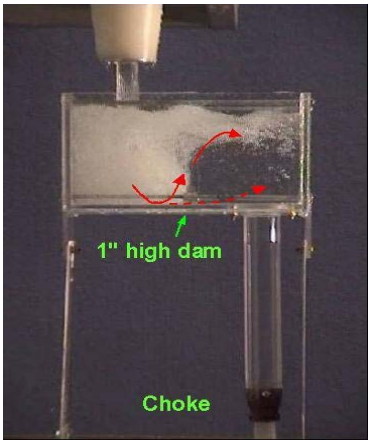

Figure 2 (b): Water modeling showing an alternative rigging practice where entrained air is removed from the pouring basin. Broken arrow in the pouring basin shows the flow path in the absence of a small dam. A choke in the sprue base slows down the flow velocity to the sprue, helping entrained air to escape to the atmosphere.

Project Partners

CANMET, Ottawa, Canada

American Foundry Society
Schaumburg, IL

Cast Metals Coalition Partnership
Charleston, SC

Canada Alloy Castings
Kitchener, Ontario, Canada

Casting Metallurgy and Process Technology, LLC, New Berlin, WI

Harrison Steel Castings Co.
Attica, IN

Industrial Ceramic Products
Marysville, OH

Matrix Metals, LLC, Richmond, TX

Maynard Steel, Milwaukee, WI

M E Global, Tempe, AZ

Sivyer Steel, Bettendorf, IA

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. Department of Energy
Energy Efficiency and Renewable Energy

July 2005