Modeling and Optimization of Direct Chill Casting to Reduce Ingot Cracking

Problem/Opportunity

The direct chill (DC) casting process is used for 68% of the aluminum ingots produced in the U.S. Ingot scrap from stress cracks and butt deformation account for a 5% loss in production. The basic process of DC casting is straightforward. However, the interaction of process variables is too complex to analyze by intuition or practical experience. The industry is moving toward larger ingot cross-sections, higher casting speeds, and an increasing array of mold technologies to increase overall productivity. Control of scrap levels is important both in terms of energy usage and cost savings. Reduction in scrap could result nationally in an estimated annual energy savings of over six trillion Btu and cost savings of over $550 million by 2020.

Approach

The DC casting model project focuses on developing a detailed model of heat conditions, microstructure evolution, solidification, strain / stress development, and crack formation during DC casting of aluminum. This model will provide insights into the mechanisms of crack formation and butt deformation and aid in optimizing DC process parameters and ingot geometry.

The project is structured as a Collaborative Research and Development Agreement (CRADA) among SECAT, ANL, Oak Ridge National Laboratory, and Albany Research Center. SECAT members that are participating in the project are: Alcan, ARCO Aluminum, Logan Aluminum, McCook Metals, and Wagstaff, Inc.
The goal of this project is to assist the aluminum industry in reducing the incidences of stress cracks from 5% to 2%.

To achieve this objective, the project team will:

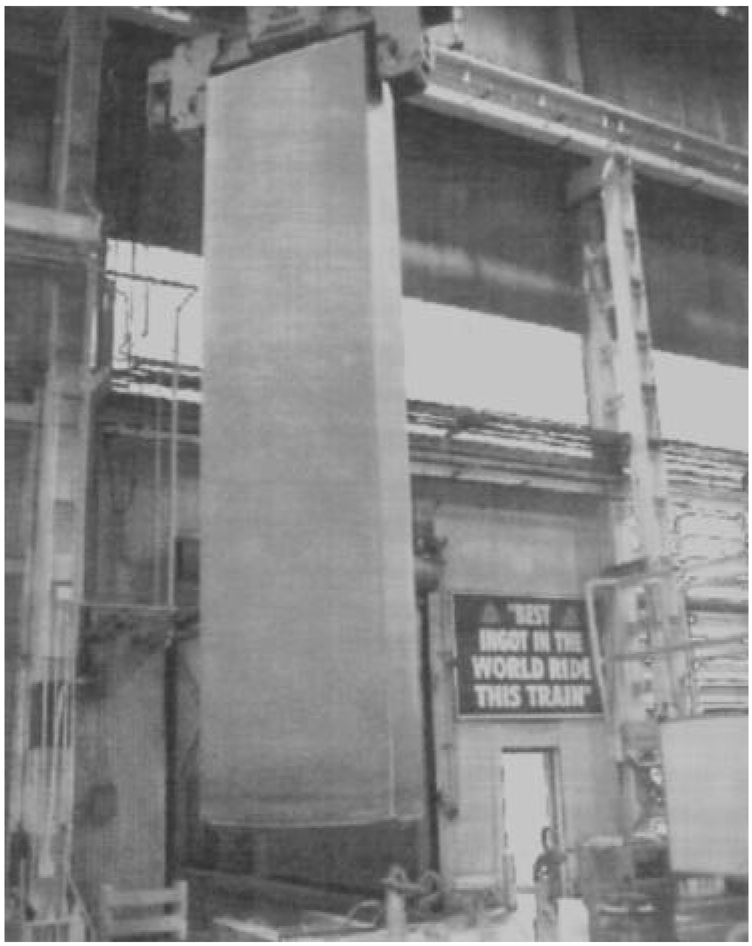
1. Conduct experimental measurements of the extremely non-uniform heat removal at the ingot surface under industrial environments.
2. Characterize ingot distortion and the solidification microstructure in detail.
3. Develop computer models of the DC casting process for predicting the fluid flow, temperature, stress fields, and microstructural evolution.
4. Determine material properties and develop criteria for crack formation based on a fundamental understanding of the interaction between the solidification microstructure, the local stress, and solidification conditions.
5. Demonstrate and validate the models for predicting crack formation and optimizing process parameters and ingot geometry.
6. Implement the models developed during this project in a commercial casting code so that they will be accessible to industry and be amenable to future refinement.

Results

This project was initiated in August 2000. Predictive modeling and increasing the general knowledge of the interaction effects could have a significant impact on aluminum ingot production losses and costs.

Future Plans

During the project, the developed technologies will be transferred to all participating companies continually during the development, validation, and demonstration phases of the project and reported in industry literature.



Direct Chill Cast Aluminum Ingot Used for the Production of Aluminum Sheet Products