ALUMINUM

Project Fact Sheet

Direct Chill Casting Model

Benefits

This project will reduce aluminum ingot scrap by developing advanced models for ingot stress crack formation and butt deformation. The potential benefits of this project include:

- improved ingot consistency and quality
- reduction in ingot scalping
- elimination of butt sawing
- annual energy savings of over six trillion Btu
- annual cost savings of more than $500 million
- emissions reduction

Applications

Approximately 68% of the aluminum produced in the United States is first cast into ingot prior to further processing into sheet, plate, extrusions, or foil. The direct chill (DC) semi-continuous casting process is the primary process used in the aluminum industry for the production of ingots.

Modeling and optimization of direct chill casting to reduce ingot cracking

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. Predictive modeling and increasing the general knowledge of the interaction effects should lower production losses to 2%. This 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.

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, butt deformation, and aid in optimizing DC process parameters and ingot geometry.

This project is a collaboration of government, industry, university, and National Laboratories. The models developed in this project will be implemented in a commercial casting code so that they will be accessible to the entire industry and amenable to refinement in the future.

Aluminum Ingot

Direct chill cast aluminum ingot used for the production of aluminum sheet products.

OFFICE OF INDUSTRIAL TECHNOLOGIES
ENERGY EFFICIENCY AND RENEWABLE ENERGY • U.S. DEPARTMENT OF ENERGY

Project Description

Goals: The goal of this project is to assist the aluminum industry in reducing the incidences of stress cracks from 5% down to 2%. This will improve productivity and product consistency as well as conserve resources and energy. These savings can be achieved because considerable amounts of cast metal can be saved by eliminating ingot cracking, reducing the scalping thickness of the ingot, and eliminating butt sawing.

Progress and Milestones

- Conduct experimental measurements of the extremely non-uniform heat removal at the ingot surface under industrial environments.
- Characterize ingot distortion and the solidification microstructure in detail.
- Develop computer models of the DC casting process for predicting the fluid flow, temperature, and stress fields, and microstructural evolution.
- 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.
- Demonstrate and validate the models for predicting crack formation, optimizing process parameters, and ingot geometry.
- Implement the models developed in this project in a commercial casting code so that they will be accessible to industry and be amenable to future refinement.

Commercialization Plan

Commercial adoption of the technologies developed in this project will occur because of active participation of Secat, Incorporated, a consortium of aluminum companies, as well as other industrial partners. 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.

The National Laboratories and University participating in the project include:

- Albany Research Center, Albany, OR
- Argonne National Laboratory, Argonne, IL
- Oak Ridge National Laboratory, Oak Ridge, TN
- University of Kentucky, Lexington, KY

Project Partners

Secat, Incorporated
Lexington, KY

Alcan Aluminum Corporation
Cleveland, OH

ARCO Aluminum, Incorporated
Louisville, KY

Commonwealth Aluminum
Louisville, KY

Logan Aluminum, Incorporated
Russellville, KY

McCook Metals L.L.C.
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December 2000