ALUMINUM

Project Fact Sheet

Prevention of Molten Aluminum-Water Explosions

New methods will prevent the onset of explosions in aluminum casting pits

Benefits

As the demand for aluminum increases, there is a greater need for increased safety and productivity. This project is:

- Developing safe casting operations and practices, resulting in safer work environments
- Improving productivity and concurrently reducing liability
- Helping to identify the cause of molten aluminum explosions

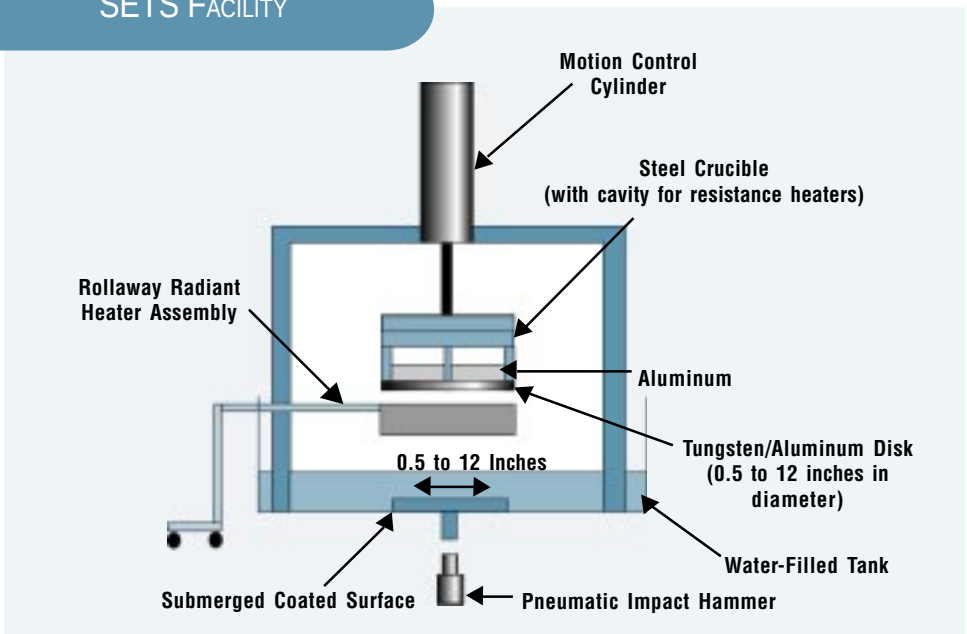
Applications

Molten metal-water explosions are a wide-spread safety concern in casting plants. The steel, pulp and paper, nuclear, phosphorous, magnesium and other metal processing industries encounter steam explosions. The results from this project will aid the metal processing industry in improving plant safety.

Most aluminum ingots are formed by direct chill (DC) casting. DC casting is accomplished by filling a shallow bottom-block and mold assembly with molten aluminum. Once the ingot profile starts solidifying, the bottom-block is continuously lowered into the casting pit while molten aluminum flows into the stationary profile. Large volumes of water is sprayed onto the newly exposed aluminum ingot walls to aid in solidifying the molten core of the lengthening ingot. During casting operations, there is a risk of a sudden release of molten metal due to process upsets onto casting equipment, pit walls or the pit bottom where water accumulates. As molten aluminum contacts the water, a steam film forms on the surface of the metal. The steam film can destabilize as the molten aluminum contacts other surfaces in the pit. When this occurs, the water spontaneously transforms from a liquid to steam leading to a high pressure steam explosion. While these explosions are infrequent, the possible consequences are a major concern for safe aluminum casting. Organic coatings on the mold and submerged surfaces can prevent these explosions by changing the destabilization dynamics.

The partners designed and developed a Steam Explosion Triggering Studies (SETS) facility. Using the SETS facility, partners investigated fundamental triggering issues, evaluated new coatings, and coating application techniques to prevent molten metal-water explosions. Project partners postulated and tested a mechanism for molten metal water explosions and evaluated new coatings and techniques to eliminate these explosions. This research project is completed.

SETS Facility



Schematic of the SETS facility located in Oak Ridge, TN.

Project Description

Goal: Improve the aluminum industry's understanding of the conditions that trigger aluminum-water explosions, including the reasons and the extent to which certain coatings prevent explosions.

Project partners conducted research into the mechanisms and prevention of aluminum water explosions. They developed a basic understanding of heat transfer from molten aluminum to submerged steel and concrete coated and uncoated surfaces. They studied the effects of non-condensable gas injection for preventing the onset of explosion. This project directly supported the Aluminum Industry Technology Roadmap industry-wide health and safety performance targets.

Progress and Milestones

These areas of research were completed and the following results were obtained:

Effect of New Coating Materials' Cure Time on Adhesion and Explosion Avoidance

Casting productivity is affected by the coating material's cure time. Four coating materials were tested and found to be useful for molten aluminum-water explosion prevention. The coatings were studied using: Differential Scanning Calorimetry, a Modified Steam Attack test, the SETS facility, a Hydrodynamic Durability test, and the Industry-Standard Molten Metal Explosibility test using cure times of less than the vendor recommended. The program established specific cure times for all four coatings to:

- withstand direct water impingement,
- provide results comparable to the durability tests at full cure times, and
- achieved acceptable explosion durability at less than 40 percent curing.

No explosions occurred with any of the four coatings at cure times below full cure even down to one hour of curing with the caveat that coating integrity is diminished at low cure times.

Concrete Scoping Tests

During limited testing, a reliable control test was not developed for molten metal explosion testing on concrete surfaces. Coating durability tests were comparable to steel.

Demonstration of Explosion Prevention with Non-Condensable Gas Injection

The use of Non-Condensable Gas Injection to prevent explosions was demonstrated in the laboratory using Oak Ridge National Laboratory's SETS facility. The research suggested that explosion prevention could be accomplished by introducing a non-condensable gas (e.g. air) into the water phase by means of perforated plates. This success did not manifest itself in the larger scale industry-Standard Molten Metal Explosion Test. Further investigation of the differences between the SETS apparatus and the fifty-pound molten metal test may be warranted.

Commercialization Plan

This work has been published in the public domain. The coatings that were tested are commercially available.

Project Partners

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