Center for Resource Recovery and Recycling (CR^3)

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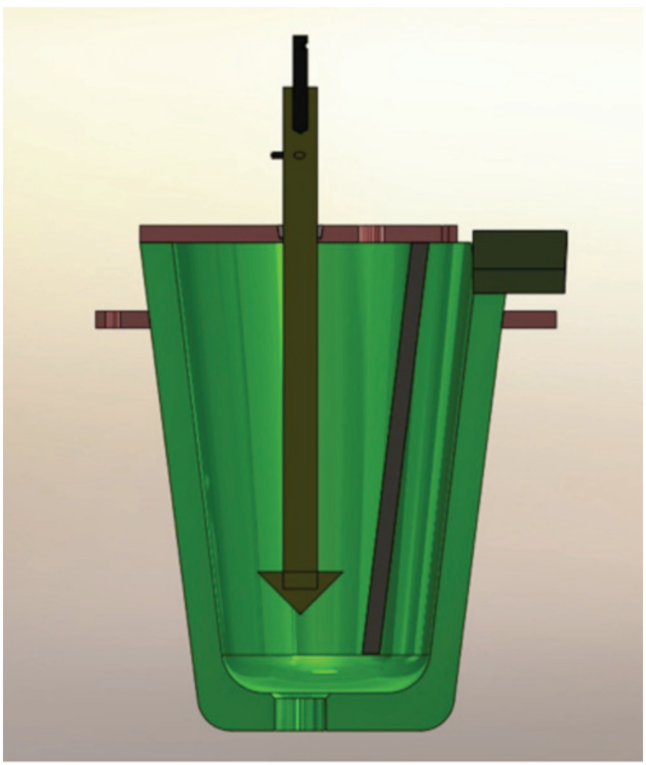
Center website: http://www.wpi.edu/academics/Research/CR3/index.html

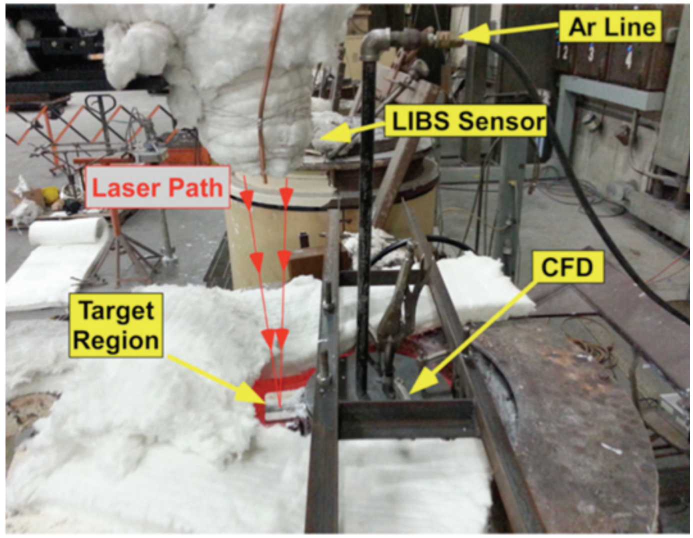
Optoelectronic In-Line Measurement of Molten Metal Chemistry



Schematic Diagram of Continuous Flow Device (CFD) enabling a continuous flow of molten Aluminum for compositional analyses or melt cognition.

An important problem that industry faces is the large amount of energy needed to produce aluminum (Al) and the commensurate gaseous emissions that the process produces. The secondary aluminum industry processes recycled scrap aluminum and expends typically 24,155 kJ/kg; to produce one kilogram of cast aluminum a considerable amount of energy is consumed. One way of reducing this energy consumption is by making better measurements of the scrap metal chemistry as it is being processed while it is molten.

The breakthrough developed at the Center for Resource Recovery and Recycling is the use of LIBS (Laser Induced Spectroscopy) to measure the melt composition as it is flowing. Such information provides process operators the ability to greatly improve the efficiency of the entire aluminum production enterprise and, in the process, significantly reduce both energy use and gaseous emissions.



Actual set up in cast house showing the LIBS and CFD devices placed on tl melting ladle.

Worcester Polytechnic Institute professor Diran Apelian and Dr. Ning Sun have developed an innovative and creative continuous flow device that makes possible measurements from fountains of molten aluminum, much as one might see in a water fountain. As a result, this breakthrough eliminates the sampling errors and enables these instruments to be commercially viable.

State-of-the-art instruments exist to accomplish this, but these have been plagued by measurement errors due to how they sample the melt. This continuous flow breakthrough represents an improvement over the previous state of the art because it enables higher-quality, field-ready instruments to more accurately measure the chemistry of molten metals. It also is more precise than previously available techniques.

This invention, termed a Continuous Flow Device, presents a clean metal stream to the measuring instruments that allow for direct detection of the aluminum chemistry without errors and provides the information instantly so immediate corrections can be made to the melt while products are being made. This level of control is unprecedented in the Al industry and should lead to large productivity gains. Current methods cannot achieve this and instead measure the metal chemistry by extracting a sample and taking the sample to an analytical laboratory. This takes time and thus does not allow for real time process control. What this breakthrough enables is reusing existing post-consumer aluminum by melting sorted scrap using melt cognition. This accordingly adjusts melt composition prior to final casting.

This breakthrough is a key piece of the Aluminum Integrated Minimill (AIM) process, a technology that will transform and revitalize the aluminum processing landscape in the US. AIM will use 100% mixed aluminum scrap as the input to produce a specification cast product in a single facility using an integrated process that only requires a single melt. The process' goal is to intelligently and effectively sort mixed scrap into a cost-effective finished product. It will reduce energy use by re-capturing the energy invested in making primary aluminum from ore and more efficiently reusing aluminum scrap to meet needs of US markets. The AIM process is to aluminum as the steel minimill is to the ferrous market.

Economic Impact: The technology will transform the secondary aluminum industry much as the advent of steel minimills transformed the steel industry. The economic benefits to industry and to the nation should be major and extremely significant. This is because energy savings should be particularly noteworthy. Use of this continuous flow instrument by the secondary aluminum industry is predicted to reduce its energy consumption by an astounding 94%. In the United States alone, this energy savings is anticipated to result in industry-wide savings of 32.9 trillion kJ/yr and a CO_2 reduction of 1.3 million tonnes/yr. In a different perspective, much energy is required to reduce the oxide of Al to produce Al metal. By using scrap Al and upgrading it, the process will save 95% of the energy that is currently used to produce the Al from its ore. This work has spun off a number of R&D contracts to further develop the Continuous Flow Device as well as the technologies it enables. One major program is the recent award of a grant from the Department of Energy's ARPA-E Program to develop an Aluminum Integrated Minimill.

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Enhanced Recovery in Foundries

There was unanimous agreement at a recent International Sand Reclamation Conference that the low rates of reuse of foundry sand is one of the highest priority problems confronting the industry. The annual generation of foundry waste (including dust and spent foundry sand) in the United States is thought to range from 9 to 13.6 million metric tons (10 to 15 million tons).

Researchers from the NSF Center for Resource Recovery and Recycling (CR^3) at Victaulic, a charter sponsor of the center, and at the Kroll Institute for Extractive Metallurgy at the Colorado School of Mines have developed a more efficient process to liberate beneficial products (clay and seacoal) from waste green sand foundry dust. The use of sand casting in US foundries is well established. Sand casting is the least expensive of all casting processes. It economically produces rough metal parts. Raw castings are then machined to produce finished products.

This breakthrough offers a more economical and more environmentally friendly processes for recovering clay and seacoal from green sand foundry dust and from waste green sand.

Through research, a hydrocyclone process was developed that doesn't use harsh chemicals and reclaims approximately 80% of the clay and seacoal from the dust. The advantage of this work for industry is that it offers a more economical and more environmentally friendly process for recovering clay and seacoal from green sand foundry dust and from waste green sand than was previously available. This work improves the method for disposing of green sand foundry dust and recycling of binding materials. Binders are materials added to a sand mold to bond sand particles together (i.e., it is the glue that holds the mold together).

Economic Impact: This breakthrough impacts original equipment manufacturers that use finished metal parts. It minimizes costs related to waste disposal of green sand foundry dust and the cost of buying bond. This CR^3 based innovation is estimated to save approximately $1 million per green sand foundry per year. By reducing accumulations of waste materials, other economic benefits will also accrue.

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