TURNING SCRAP ALUMINUM INTO A HIGH-VALUE PRODUCT

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TITLE: Development of an Integrated Minimill for the Aluminum Industry: From Scrap to Product in One Step

PROGRAM: Modern Electro/Thermochemical Advances in Light Metals Systems (METALS)

AWARD: $3,815,131

TEAM: Energy Research Company, WPI, wTe, Melt Cognition

TERM: January 2014 – September 2018

PRINCIPAL INVESTIGATOR (PI): Robert De Saro

MOTIVATION

In recent years, automakers have begun to increase fuel economy and performance in their vehicle fleets by replacing steel components with lighter aluminum alloys. Industry estimates indicate that aluminum use in vehicles will increase by more than 40% by 2028.[1] Increased use in the auto industry creates new post-consumer waste streams that generate large amounts of mixed metal alloy scrap, which contain significant embodied energy. Currently, this scrap and its embodied energy is largely wasted in reuse; it is too expensive to sort out specific alloys using existing technology. As such, much of the scrap metal is shipped overseas to countries with low cost, manual labor to be hand sorted and converted to lower grade metal products. A means to cost-effectively recycle aluminum alloy scrap into a high quality product in the United States creates a three-pronged opportunity to reduce energy consumption: through vehicle light-weighting, in primary energy demand from aluminum production and recycling, and through decreased exports of scrap metals and their embodied energy.

TECHNICAL OPPORTUNITY

Automakers are interested in producing high-quality aluminum from recycling due to forecasted increases in scrap production. The growing demand requires an aluminum minimill that can separate, clean, melt, and certify that alloy from scrap has the same quality as new. The scanning technology for identifying metal alloy pieces is used in the medical diagnostics industry, but it lacks the accuracy and automation necessary for this application. Likewise, food processors use high-volume sorters, but they have not been adapted for alloys. Melters exist that can perform the job, but not with the kind of autonomy necessary. Laser-induced breakdown spectroscopy (LIBS) can measure solid metal, but it had never been used to measure molten aluminum at a commercial plant prior to this project. These approaches have never been successfully integrated. The challenge is to do so cost effectively and to apply the technology to a very risk-averse industry.

INNOVATION DEMONSTRATION

Traditional aluminum alloy scrap recycling has a large and disparate value chain that requires efficient sorting, cleaning/melting, casting, and recertification to be profitable. These steps are performed at separate facilities. The ERCo team identified inefficiencies in scrap sorting, integrated waste heat reclamation from de-coating, and scrap melters. ERCo's aluminum integrated minimill (AIM) integrates alloy recycling into one process at a single facility (Figure 1) located near the factory where scrap is processed, and where the certified product may be effectively used without costly re-melting of the product for transport. In addition, each of AIM's components listed below adds to the overall energy efficiency improvement and emissions reductions:

1 Aluminum Use in Autos Advances, Recycling Today, http://www.recyclingtoday.com/article/aluminum-automotive-content-usa-growing/, 11/7/17

Sorter: First, a sorter divides aluminum scrap pieces (known as "twitch") into individual alloy bins. The ERCo team's original effort was suitable for heavy metals such as copper, but AIM needs an accurate and cost-effective sorter for aluminum alloy scrap. ERCo is integrating the sorter from UHV Technologies, another ARPA-E METALS performer, which uses X-ray fluorescence detectors to auto-sort aluminum alloys. UHV is providing ERCo with a pilot sorter for AIM integration in 2018.

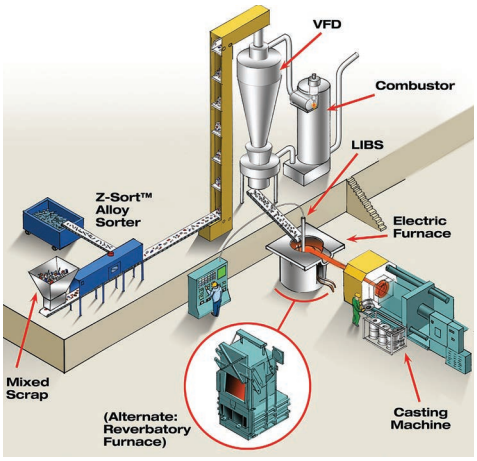

Figure 1: Diagram of ERCo's AIM: the world's first system capable of reclaiming virgin-like aluminum alloy from scrap at manufacturing sites.

Vertical floatation de-coater (VFD): ERCo's VFD unit then uses aerodynamics and conventional heat transfer to remove organic impurities such as oil or paint from a given alloy. High velocity gas flows simultaneously separate and heat scrap pieces to de-coat materials at lower temperatures than other techniques. This system can produce 99% organic-free metal scrap material that requires no further treatment—a major improvement over the more traditional techniques of oil dissolution and flame pyrolysis.

Melter: Once the scrap is cleaned, it is melted to be cast into a form that can either be transported or sold. AIM can be used with any melting equipment. While melting itself does not represent a technological innovation, melting alloy onsite for immediate use directly represents an energy savings of about 30%.

OnSpec for melt chemistry measurements: Finally, a LIBS analysis unit (branded OnSpec) measures the chemical composition of molten aluminum in situ and in less than two minutes by a probe immersed in the molten metal. The plasma caused by an incident laser can quickly determine the melt's exact composition, representing a greater than 50% energy savings over melting and certifying virgin metal ingot from a foundry.
AIM's collective improvements to the process are projected to save more than 80% of the energy needed to make aluminum products, compared to conventional methods.

IMPACT PATHWAY

The OnSpec technology is the first of this project's technical components to reach commercial maturity. VFD has also been well received in the industry. Six successful demonstrations of the OnSpec technology have been undertaken at commercial industrial plants, leading to licensing of the technology to Altek, a Pennsylvania-based manufacturer of industrial test equipment.

In addition, ERCo founded a joint venture, Melt Cognition, with several partners to further develop and commercialize the AIM system. ERCo has successfully raised about $1.8 million in follow-on funding, while Melt Cognition is raising funding to integrate the AIM components into a single pilot plant at a commercially operating aluminum processor.

LONG-TERM IMPACTS

The AIM could reduce energy usage in the U.S. aluminum metal casting industry and repurpose the aluminum scrap streams for use by domestic industry, rather than have this valuable, energy-intensive product exported. If widely adopted by U.S. industry, AIM could eliminate more than 80% of the total energy required for aluminum production, increase metal yield, allow the use of lower cost scrap, and reduce wasted embodied energy in aluminum scrap.

INTELLECTUAL PROPERTY AND PUBLICATIONS

As of January 2018, the ERCo team's project has generated three invention disclosures to ARPA-E. Three U.S. Patent and Trademark Office (PTO) patent applications have been filed on the disclosed inventions.