CHANGING WHAT'S POSSIBLE

ELECTRODYNAMIC SORTING OF LIGHT METALS AND ALLOYS

Updated: January 10, 2018

TITLE: Electrodynamic Sorting of Light Metals and Alloys

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

AWARD: $2,980,000

TEAM: University of Utah

TERM: January 2014 – March 2018

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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

One major challenge with aluminum recycling is sorting. Scrap metals rarely manifest in a clean, high-purity state, but instead bundle together in dirty mixtures of several distinct metals. The recycling industry would benefit significantly from a technology that can reliably sort aluminum and its alloys from fine-sized feedstocks with high throughput. Unfortunately, many technologies suffer from major technical limitations in attempting to meet this goal. For example, dense media separation is an expensive, highly regulated process that requires heavy capital investment and can cost as much as $70/ton. It is also incapable of sorting metals with similar densities (e.g. copper and zinc) or that are very small (less than 4 mm radius). Methods based on x-ray fluorescence (XRF) are also available, but require a two-step process of analysis and separation for each individual particle. As a result, XRF struggles with throughput demands when particles are very small (typically less than 2 cm radius).

INNOVATION DEMONSTRATION

Electrodynamic sorting (EDX) is a technology developed with ARPA-E support at the University of Utah. It is similar to a traditional eddy current separator in that it uses time-varying magnetic fields to sort scrap. As a metal particle passes through the alternating magnetic field, electrical eddy currents are induced throughout its volume and give rise to a distinct, repulsive force. Instead of mechanically rotating a fixed drum of permanent magnets, however, EDX utilizes a fixed array of stationary electromagnets (Figure 1). Thus, without the limitation of moving parts, the EDX technology can achieve far higher frequencies of magnetic excitation. While a traditional eddy current separator may reach as high as 1 kHz, the EDX magnets can excite metal particles with frequencies as high as 50 kHz or more. This allows EDX to recover far smaller particles of scrap metal, since smaller particles

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

often require higher frequencies in order to significantly deflect. Through the proper choice of frequency, it also becomes possible to sort non-ferrous metals by both conductivity and density (e.g. aluminum from copper). The process is clean and dry, thereby eliminating the environmental concerns that arise with flotation-based methods.

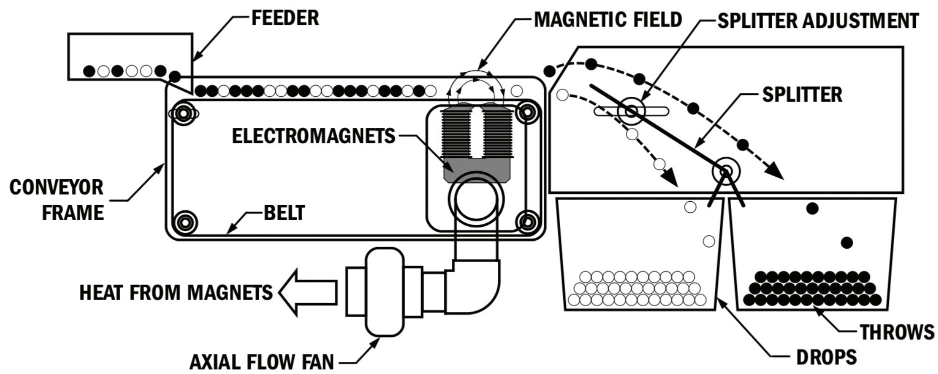

Figure 1: A schematic of a solid-state electrodynamic sorter.

To date, the EDX testbeds have demonstrated reliable sorting with scrap mixtures ranging in particle size from 1 to 30 mm. The prototypes have successfully sorted copper scrap from heavy brass mixtures and also separated aluminum scrap from copper/brass/zinc mixtures. Typical grade, or purity, of the recovered metals can reach as high as 97% with recovery values likewise reaching well over 90%. The technology has also demonstrated a capacity to sort aluminum scrap metals by alloy, which can add significant value for scrap metal recycling. Throughput rates are also very promising, with current testbeds reaching 0.25 tons/hour (t/h). In the future, next-generation testbeds are expected to pass the 1.0 t/h threshold typically demanded by industrial-scale recyclers. Finally, the EDX systems are expected to be cost-effective to operate, with typical operating costs as low as $1.00-2.00/t for energy and labor. Likewise, assuming a mere $0.10/lb in value added after sorting, an EDX machine operating at 0.5t/h could generate $100/h in revenue.

IMPACT PATHWAY

EDX Magnetics LLC, was formed in 2017 to commercialize this technology. This small business intends to license the intellectual property of EDX from the University of Utah and manufacture the basic drive electronics (magnetic cores, amplifiers, process controls, etc.). A second joint venture company will likely be necessary to manufacture the conveyor system, catch basins, and feeding mechanisms.

LONG-TERM IMPACT

The EDX technology could reduce energy usage in the U.S. aluminum metal casting industry and repurpose U.S. aluminum scrap streams for use by U.S. industry, rather than export this valuable, energy-intensive material. Since aluminum recycling is also far more energy efficient than mining and processing new ore, this process could help save as much as 1% of total U.S. electricity consumption. Furthermore, by extracting more of the finely sized particles inaccessible to traditional sorters, EDX can potentially save another 0.5 million metric tons of aluminum metal annually that today ends up in landfills.

INTELLECTUAL PROPERTY AND PUBLICATIONS

As of January 2018, the Utah team's project has generated two invention disclosures to ARPA-E. The team has also published three times the scientific underpinnings of this technology in open literature.