REMADE INSTITUTE

RECYCLING & RECOVERY

RAPID SORTING FOR SCRAP METAL RECYCLING

Electrodynamic sorting uses magnetic fields to separate different types of nonferrous metals.

From soda cans to aircraft, aluminum goes into a vast array of products—and often finds its way back into these products as recycled scrap. Secondary production of aluminum from old scrap amounted to only about 29% of the nation's total use in 2022.[1]

Given that recycled aluminum takes 92% less energy to make than primary aluminum does,[2] unused scrap represents a large amount of domestic energy waste. Recovering and recycling a larger share of this inherently recyclable metal requires better sorting technology.

The challenge of extracting aluminum from mixed scrap metal is heightened by the presence of particles 3 centimeters or smaller. The more difficult a waste stream is to sort, the more likely it is to be sent to other countries or to a landfill. The U.S. exports about 2 million metric tons of scrap aluminum in a year,[3] and well over 2 million metric tons was landfilled in 2018 alone.[4]

Researchers at the University of Utah are developing a solution: electrodynamic sorting, or EDX. Using time-varying magnetic fields, EDX can sort aluminum from a scrap metal mixture containing particles measuring 1–2 centimeters. The technology can also further sort aluminum particles by alloy composition, increasing the potential to maximize scrap metal value.

PROJECT DESCRIPTION

Working with partner EDX Magnetics, the researchers set out to address the current limitations of EDX in this 18-month project. Though EDX was a proven concept, it did not yet possess the necessary throughput or recovery values to warrant widespread industrial adoption.

In a laboratory testbed, for example, EDX could process about 0.25 metric tons per hour of automotive shred residue at particle sizes between 0.25 and 3.0 centimeters—known as fine Zorba—and achieve 90% or greater aluminum purity. However, for materials between 0.25 and 1.0 centimeters, the recovery rate lingered at about 50%.

The project goals were to:

- Achieve 90% recovery of scrap aluminum from Fine Zorba (0.25–3.0 cm) while maintaining 90% purity
- Increase throughput of a single pass Zorba EDX system to 0.75 metric tons per hour
- Develop a magnet package to sort aluminum into cast and wrought alloy groups in real world material with an 80% recovery and 80% grade of wrought alloy at 0.10 tons per hour.

The researchers began by characterizing samples of fine Zorba by X-ray fluorescence, breaking down the metals contained, their fractional mass proportions, electrical conductivities, and major aluminum alloy families. They used this information to model the kinematic behavior of various particles as the particles traveled through an applied magnetic field. The model's accuracy was validated against experimental trials by monitoring particles with slow-motion capture as they passed through the EDX system. Varying magnetic core geometries and electrical drive conditions were modeled, informing the design and construction of EDX system upgrades.

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[1] United States Geological Survey (USGS), *Mineral Commodity Surveys 2023: Aluminum*. January 2023. https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-aluminum.pdf. Accessed October 16, 2023.
[2] Aluminum Extruders Council, Sustainability. https://aec.org/sustainability. Accessed October 17, 2023.
[3] USGS.
[4] U.S. Environmental Protection Agency, Aluminum: Material-Specific Data.

PROJECT IMPACT

The numerical models developed for this project models enable the development of a new generation of eddy current separators optimized for metal sorting.

The team constructed a new electrodynamic sorting assembly capable of processing fine Zorba at a rate of well over 1 metric ton per hour. Aluminum recovery reached 84% with a purity of 97%. The EDX concept's system architecture was advanced with the use of power transformation, which dramatically reduced the capital investment cost of the technology. The work also greatly optimized the system's thermal management.

By more efficiently extracting aluminum from mixed scrap, this project has the potential to reduce primary material consumption by 0.15 MMT per year, reduce embodied energy use by 27 PJ per year and reduce CO2 emissions by 1.55 <<T per year.

NEXT STEPS

The system needs several modifications, which are detailed in the final project report. These include upgrades to improve material sorting and to ensure survivability and performance in a harsh environment. With these changes, the EDX technology will qualify as a commercial-ready technology that can be installed at a scrap recycling facility.

PROJECT PARTNERS

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PUBLICATIONS

Rajamani, R.K. and Nagel, J.R. Rapid Sorting of Scrap Metals with Solid-State Device: Final Report for REMADE Project: 17-FP-RR-01. January 2020.

Nagel, J. R., Cohrs, D., Salgado, J., and Rajamani, R. K., Electrodynamic Sorting of Industrial Scrap Metal. 2020. *KONA Powder and Particle Journal*. Vol. 37, pp 258–264. https://doi.org/10.14356/kona.2020015.

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Nagel, J. R. An analytic model for eddy current separation. Minerals Engineering, Vol. 127, 2018, pp 277-285. https://doi.org/10.1016/j.mineng.2018.08.025.

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