Comminution and Electrodynamic Eddy Current Separation Studies of End-of-Life Photovoltaic Materials

York R. Smith*, Pamela Bogust, and Raj K. Rajamani
Department of Metallurgical Engineering, University of Utah
*e-mail: york.smith@utah.edu

IEEE Photovoltaic Specialist Conference 2017, Washington, D.C.

BACKGROUND

• Photovoltaic materials have been the focus of recent work on resource scarcity and material criticality [1-3].

• Overburden of end-of-life (EOL) solar panel materials is currently not an issue, as many panels have yet to reach their maturity (15-20 years).

• The annual waste from the photovoltaic industry from EOL panels is expected to be 280,000 tons (2016 estimate), and according to early-loss scenarios, this value could reach up to 78 Mt by 2050 [4] (Fig. 1). Currently, most EOL PV materials are disposed in landfills as an economically viable recycling process has yet to be realized.

• Rotary drum eddy current separators (Fig. 2(a)) have demonstrated industrial recovery of non-ferrous metals (e.g., Al, Cu, Pb, brass). Excitation frequency (~1 kHz) limited by rotary speed of magnets and struggle to economically recover particles >5 mm.

• New design (Fig. 2(b)) has minimal mechanical parts and higher excitation frequencies are achievable (~50 kHz).

• Previously has demonstrated successful sorting of Al/Cu, Cu/Brass, Al/Brass, and Al-Cu series alloys (i.e., Al-110/Al-2024, Al-110/Al-6061, and Al-6061/Al-2024 mixtures) [5].

OBJECTIVES

• Examine the efficacy of EECS to recover valuable materials from EOL PV modules.

• Comminution studies of PV materials.

• Examine methods of beneficitation and overall energy requirements for PV recycling.

EXPERIMENTAL METHODS

• Experimental setup shown in Fig 2. For a more detailed description see reference [5].

• Particles (granular chunks) 1-3 mm in diameter (Si, Al, CdTe, American Elements, 99.9%) used for separation.

• Ferrite core (CMD5005 NiZn ferrite), OD of 160 mm and ID of 120 mm, with a custom 1.1 cm gap. The core was wound with two windings in parallel on either side of the gap.

• 400 W power supply, operating at 52.8 V and 6.6 A with resonance frequency of 21.4 kHz, B ~ 60-80 mT.

• 200 g of each material used for a total of 400 g per sorting experiment.

RESULTS & DISCUSSION

• The results of the experimental campaign [6] demonstrate the capability of this technology to separate Si/Al and CdTe/Al particles mixtures of 1-3 mm with recoveries and grades >85% under the given conditions.

• Deviation from a perfect sort due to non-spherical particles (especially thin sheet-like particles which do not kick as strong) and how the particles are fed to the core gap.

• Although energy consumption is low, the throughput needs to increase by an order of magnitude while maintain high recovery and grade (>95%) if commercial application is to be realized.

• Milled PV panels will have much smaller particles, requiring greater excitation frequencies.

• EECS of Si/Al and CdTe/Al 1-3 mm particles mixtures is successfully demonstrated; however, separation of smaller particles approaches the physical limitations of the system. The technology may be better utilized as a pre-concentration step.

• Future work includes detailed studies on the comminution of PV materials to understand the breakage kinetics, particle size distribution and composition, and energy demand.

• Removal of ethylene-vinyl acetate (EVA) has initially been investigated by various means such as thermally or chemically (Figure 3).

• Cryogenic milling experiments.

CONCLUSION & FUTURE WORK

• EECS of Si/Al and CdTe/Al 1-3 mm particles mixtures is successfully demonstrated; however, separation of smaller particles approaches the physical limitations of the system. The technology may be better utilized as a pre-concentration step.

• Future work includes detailed studies on the comminution of PV materials to understand the breakage kinetics, particle size distribution and composition, and energy demand.

• Removal of ethylene-vinyl acetate (EVA) has initially been investigated by various means such as thermally or chemically (Figure 3).

• Cryogenic milling experiments.

ACKNOWLEDGMENT

YRS and PB would like to acknowledge support provided by the U.S. Department of Energy, Office of Science, Energy Efficiency & Renewable Energy, SunShot Initiative. This publication was developed under an appointment to the Energy Efficiency and Renewable Energy (EERE) Research Participation Program, administered for the U.S. Department of Energy (DOE) by the Oak Ridge Institute for Science and Education (ORISE). ORISE is managed by ORAU under DOE contract number DE-SC0014664. This document has not been formally reviewed by DOE. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of DOE, or ORAU/ORISE. DOE and ORAU/ORISE do not endorse any products or commercial services mentioned in this publication.

REFERENCES