INFINIUM Magnesium

August 24 – 25, 2016
Detroit, MI

METALS Annual Meeting

Mg Alloy Scrap → Clean → Melt

Pure Mg

Impurities A

<1 kWh/kg Energy

Impurities B

ER

S1

S2

Mod
Agenda

- Team Intro
- Motivation
- Technical Concept
- Technical Progress to date
- TEA Highlights
- Demo Requirements
- Future Goals/Closing Thoughts
- Q&A
The INFINIUM Team

Clean Metal Production for Clean Energy

Team Members
- Adam Powell, PI
- Aaron Tajima, project manager, lead designer
- Matthew Earlam, TT&O lead

Project Summary
- New process for magnesium alloy refining/recycling
- Very low energy: <1 kWh/kg product
- Continuous → low capital and labor costs
- High purity product suitable for low-corrosion alloys
- Liquid metal product
- Small machine, very high throughput
- Very low total cost

Current Goals
- Proof-of-concept technology demonstration at ≥1 kg/hr scale
- Scale-up magnesium refiner design with energy use <1 kWh/kg
Motivation

- Mg could reduce vehicle weight, energy use and emissions more than Al provided several barriers can be overcome:
  - Recycling scrap → vehicle parts
  - Low-cost secure primary supply
  - Warm/cold-formable sheet
  - Improved corrosion behavior
  - Multi-material joining
  - Large thin-wall castings

This high risk project addresses two key barriers to increased Mg use:

- Mg recycling difficulties today:
  - Impurities: due to attachments etc. sorting can not achieve purity for low-corrosion alloy specs AZ91D/E, AM60B/C – too much Fe, Cu, Ni
  - Liquid Mg handling: requires cover gases to prevent fire
  - Poor safety track record: many Mg recycling companies have had explosions/fires
  - Result: post-consumer Mg alloy scrap recycling rate is 20-30% • Compare to 60-80% for steel and aluminum
Technical Concept

- **INFINIUM Mg refining technology:**
  - Continuous → low labor, capital
  - Low energy <1 kWh/kg product
  - Purity suitable for new vehicle parts

- **Barriers/risks:**
  - Very novel separation methods
  - Materials: liquid Mg is ok, Al and others are difficult
  - Reactivity: can’t hold Mg in open containers without cover gas e.g. SF₆

- **Today’s technologies for Mg refining:**
  - Distillation: 5-7 kWh/kg, slow batch process, high surface area pyrophoric solid “crown” product requires remelting
  - Electrorefining: 4-5 kWh/kg, slow continuous process
Technical Progress to Date

Project phases:
- Foundation: materials selection, component/subsystem testing, lab-scale system design
- Proof-of-Concept: first implementation
- Technology development: lower energy use, higher product purity
- Post-project demonstration: much larger throughput

Current status:
- Six months in, Foundation phase is nearly complete
- Moving forward with component/subsystem test stand fabrication and design of first complete recycler
- Project end date: February 2018

Biggest successes to date:
- Successfully tested some of the novel subsystems, all of which must work to make the overall system succeed
- Identified and tested candidate materials for system components
TEA Highlights

- **Price range**: this will be competitive at world (ex-US) magnesium prices
  - *Low enough cost to increase scrap value and incentivize higher recycling rates*

- **Energy/emissions**:  
  - <1 kWh/kg  
  - Direct emissions only from scrap cleaning and melting

- **Benefits**:  
  - Much lower cost than other refining processes  
  - Much better purity than any sorting technology can achieve alone  
  - Small fraction of the cost of primary production

- **Typical plant scale**: 5000-20,000+ TPY
Demo Requirements

- If this project succeeds, the Demonstration phase will build and test a small industrial refiner
  - Scale: ~1000 TPY
  - Cost Range: very low
  - Projected Outcomes: economical for refining, will need to quickly grow scrap supply to keep up with production

- Partnership requirements
  - Working on market analysis and potential partners – including finance – to enable successful Demonstration phase
Future Goals/Closing Thoughts

- **Two-year project end goals:**
  - All technical problems solved, working system at large lab scale
  - Complete design for Demonstration phase ready to start fabrication

- **5-10 year vision:**
  - 20-30 kT/yr magnesium recycling output in US, Europe, Japan
  - Increased magnesium alloy scrap availability by providing a market for nonferrous sorters
  - Begin scale-up of primary production enabled by this technology

- **Prospective impact:**
  - Meet goals of Mg 2020 report (USCAR 2006) → replace 630 lbs steel/aluminum components per vehicle with 340 lbs magnesium which have already been done before
  - Enable new magnesium-intensive vehicles like Ford/Magna MMLV Mach II with >40% weight reduction
  - Lower oil imports and transportation sector energy/emissions
QUESTIONS?