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PRODUCTION OF MAGNESIUM AND ALUMINUM-MAGNESIUM ALLOYS FROM RECYCLED SECONDARY ALUMINUM SCRAP MELTS

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Abstract - An experimental proof of concept was demonstrated for a patent[1] and trademark[2]-pending RE-12^{TM} process for extracting a desired amount of Mg from recycled scrap secondary Al melts. Mg was extracted by electrorefining producing Mg product suitable as Mg alloying hardener additive to primary grade Al alloys. This efficient electrorefining process operates at high current efficiency, high Mg recovery and low energy consumption. Mg electrorefining product can meet all the impurity specifications with subsequent melt treatment for removing alkali contaminants. This economical and environmentally friendly chlorine-free RE-12^{TM} process could be disruptive and transformational for the Mg production industry by enabling the recycling of 30,000 tonnes of primary-quality Mg annually.

Introduction - North America produces only ~70,000 tonnes of primary Mg annually. The only practical recycling of post-consumer Mg is as alloying content in the Al-alloy recycling system. However, in that system over 30,000 tonnes is chlorinated or fluxed out to end up as Mg chloride contamination of dross.
The objective of this project was to develop a proof of concept on a laboratory scale of an electrorefining process to recover Mg from secondary Al alloy melts sourced from domestic Al alloy scrap feedstock and to produce primary-quality Al-Mg alloys.

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Process Concept - The process concept for extraction of Mg from Al scrap was designed to fit with existing Al remelting and recycling processes. Al is typically resmelted in a sidewell reverberatory furnace and the Mg is chlorinated out of the melt by continuous injection of Cl_2. In the RE12^{TM} process, Cl_2 injection and Mg chlorination is replaced by Mg electrorefining and Mg recovery for recycling.

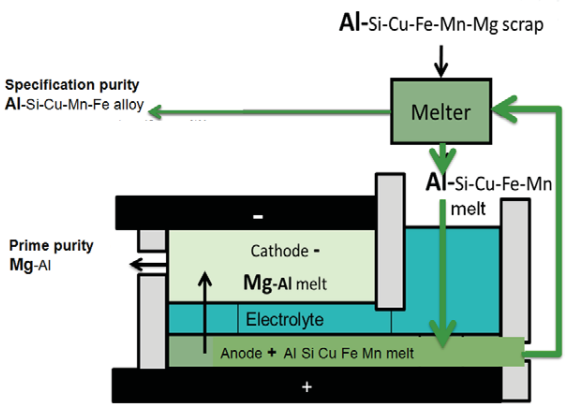

Figure: Illustrates the RE12™ process concept and its conceptual integration with an Al melter in an Al secondary smelter.

Experimental Results: Demonstrated performance of RE12™ electrorefining process

We characterized the refining cell performance and determined the optimum electrorefining configurations that resulted in a stable operation well below the target specific energy consumption of <10 kWh/kg Mg. We conducted a series of electrorefining experiments designed to measure key process operating parameters and milestone metrics as described below.

Metrics	Achieved	Target
Cell voltage @ CD 0.9 A/cm^2 (V)	1	<4
Energy consumption at 0.9A/cm^2 (kWh/kg Mg)	2.5*	<10
Current efficiency (%)	~100	>90
Cathode Mg recovery (%)	>93	>90
CO_2 emission (kg CO_{2eq} / kg Mg)	< 4	<1
Production cost ($/kg)	< $2	$1.7

* not including melting heat required from scrap and other external heat losses

Conclusion – Experimental results obtained indicate that the electrorefining process for extraction of Mg from Al melt is technically feasible. Our techno-economic analysis[3] indicates high potential profitability for applications in Al foundry alloys as well as beverage can and automotive sheet alloys.

References

1. Gesing, S. Das and M. Gesing, "Electrorefining of Mg from Scrap Metal Al or Mg Alloys", Patent Application US 2015/0225864 A1, 2015 (Phinix, LLC)
2. Phinix, LLC - Trade Mark RE12[12] Recycled Mg, 2014
3. Gesing, S. Das, and R. Loutfy, "Production of Mg and Al-Mg Alloys from Recycled Secondary Al Scrap Melts", full paper to be published in the Journal of Metals.