PLASMA ARC GASIFICATION BASED RARE EARTH ELEMENT RECOVERY FROM COAL FLY ASH

Jay E. Renew, P.E.[1], Ken Jeffers, P.E.[1], Kevin Davis, Ph.D.[2], Rod Vera[3], Victor Filatov[3], and Jacob Beutler[2]

[1]Southern Research, [2]Reaction Engineering International, and [3]ArcSec Technologies

2000 9th Avenue South, Birmingham, Alabama 35205, kjeffers@southernresearch.org

Collaborators

REACTION ENGINEERING INTERNATIONAL

ArcSec Technologies

THE UNIVERSITY OF UTAH

HEADWATERS RESOURCES

Background

- US bituminous coal fly ashes (CFAs) have been estimated to have an average total rare earth element (REE) content of approximately 517 ppm (Blissett, Smalley, & Rowson, 2014; Ketris & Yudovich, 2009; Seredin & Dai, 2012).
- In the US, approximately 48.4 million metric tons of CFA were produced in 2013 (2013 Coal Combustion Product (CCP) Production & Use Survey Report, 2013).
- Approximately 21.2 million metric tons were beneficially utilized leaving in 27.2 million metric tons of CFA for landfill disposal (2013 Coal Combustion Product (CCP) Production & Use Survey Report, 2013).
- If an average CFA REE content of approximately 517 ppm is assumed, approximately 14,083 metric tons of REEs are available for recovery.

Technology Options

1. **Plasma smelting - objective is to separate CFA into a Al_2O_3-SiO_2-Ca rich layer and metal matte where denser metals (including REEs) will accumulate.**
2. **Plasma smelting plus sequential condensation - metal matte (enriched with REEs) will be volatilized by raising temperature and recovered through sequential condensation.**

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Project Objectives

1. Conduct sampling and characterization of potential feedstock CFAs from 8 coal fired-power plants that utilize eastern bituminous coal.
2. Conduct bench-scale experiments utilizing a plasma furnace to evaluate partitioning of REEs to the metal matte. Evaluate potential enhancements to promote REE partitioning to the metal matte.
3. Model plasma volatilization of the molten matte. This model will also include sequential condensation of REE enriched material from the gas phase.
4. Perform feasibility study of the proposed technology.
5. Detailed design of pilot-scale unit for Phase II testing.

Modeling Fe in CFA Melting

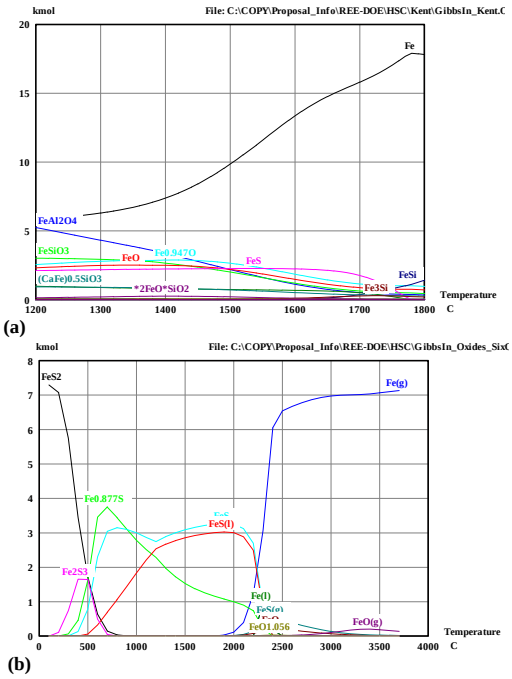

Figure 1. Equilibrium concentrations of Fe containing species in (a) Kentucky (Dean) CFA (b) PRB (Eagle Butte) in reducing environment when heated to 1,200 ºC to 1,800 ºC.

Sequential Composition

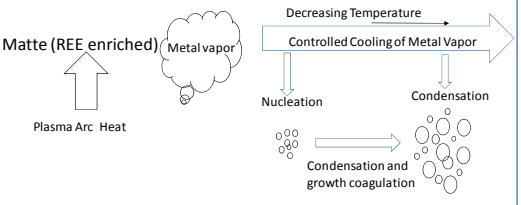

Figure 2. Plasma volatilization plus sequential condensation.

Modeling REE Volatilization

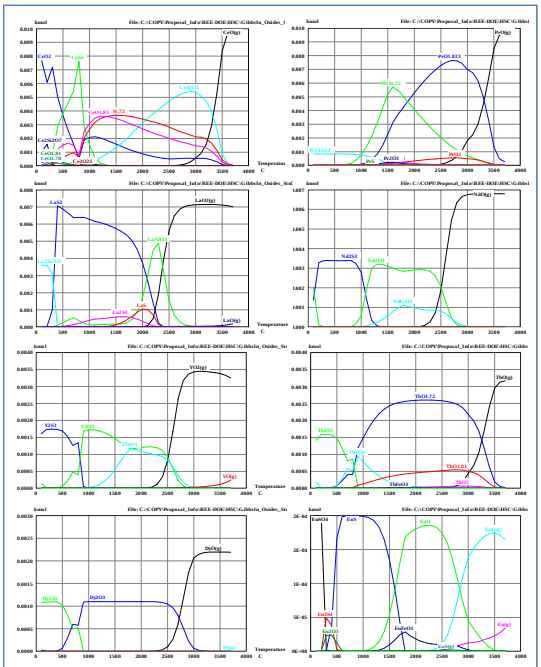

Figure 3. Equilibrium concentrations of REE containing compounds from a mixture of PRB (Eagle Butte) coal ash in a reducing environment at up to 3,700°C.

Plasma Reactor

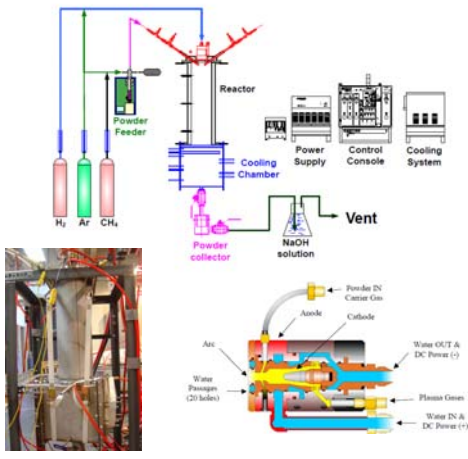

Figure 4. Plasma reactor and gun.

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