Applications in Our Nation’s Industry

ADPIN magnetic powders will have a variety of benefits to industries requiring REEs. The near-term target market is magnetic refrigeration because of ADPIN’s high saturation magnetization; this allows for increased cooling power in refrigeration engines without changing cost, while improving electrical efficiency and environmental benefit. Longer-term applications include wind turbines, electric vehicles, and manufacturing robotics. These markets emphasize PM applications with higher coercivity and energy density.

Project Description

The project objective is to design, develop, and demonstrate a fluidized bed reactor that yields a 100-fold increase in the amount of alpha double prime iron nitride (ADPIN) powder for the development of rare earth free, high performance permanent magnets. This project aims to accomplish this via two different fluidized bed reactor (FBR) designs: initially utilizing a transparent fused quartz processing chamber that allows for direct observation of the fluidized bed at operating temperatures and pressures. The project outcomes address the current technical challenge that hinders ADPIN magnetic powder usage: large
scale production. The project will utilize a three-step process: 1) nitriding & quench to achieve an austenitic phase (γ-(Fe,M):N); 2) cryo-deformation to transform the austenitic phase to a martensitic phase (α’-(Fe,M):N); and 3) annealing to transform the martensitic phase to the ADPIN (α"-(Fe,M)16N2) phase.

Barriers

- Accelerating production for the nitriding and quenching step (current lab-scale process takes weeks to produce enough 99% pure material for a single cubic centimeter magnet)
- Addressing changes in heat transfer for a full-scale FBR system using a stainless-steel process chamber

Pathways

The project is structured to address the key barriers and minimize risk. The ultimate goal is to develop FBR technology for the prototype scale production of ADPIN magnetic powders.

The first project pathway will model and experimentally validate fluidization parameters for the FBR. This validation will involve demonstrating effective gas velocity and pressure drop across the bed as a function of particle size and density for a bench-top room-temperature fluidized bed test cell. Each of these lab-scale validations will be completed on site.

The second pathway will design, develop, and demonstrate the FBR over two generations. The first generation FBR will use a transparent fused quartz processing chamber for direct visualization and comparison purposes. The second generation FBR will utilize a stainless-steel processing chamber for prototype scalability purposes. These FBRs will also be fabricated and demonstrated on site.

The third pathway will cryomill and anneal the second generation FBR output into the ADPIN magnetic powders. The cryomilling and annealing processes will transform the austenitic phase FBR output into a martensitic phase (after cryo-deformation), and then the ADPIN phase (after heat treatment).

Milestones

This two-year project began in May 2018.

- Demonstrate fluidization of 500 grams iron powder at process temperatures of ≥500°C for ≥1 hour (2019)
- Demonstrate a scalable prototype FBR-based process technology that yields a greater than 100-fold increase in the amount of ADPIN material produced by the current state of the art process (2020)

Technology Transition

FeNix Magnetics is partnering with Case Western Reserve University (CWRU) for the development and testing of the FBR to produce ADPIN powders. Following successful development, the project team plans to have an intellectual property licensing agreement negotiated with CWRU. It is anticipated FeNix would be a manufacturer and seller of ADPIN powders and magnets, through a combination of in-house and tolled processing capabilities. As a seller, FeNix would likely channel initial distribution through a limited set of strategic partners, which would focus product development on a few well-defined and specified target markets.

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