Electromagnetically Enhanced Hydrocyclone for Magnetite Separation during Coal Beneficiation

Overview
Consol Energy uses magnetite in a dense media slurry to separate mineral matter from coal. It is essential for magnetite to be recovered in a downstream process for reuse in the plant, as the price of magnetite is increasing to nearly $300/ton. The current recovery requires permanent magnetite in magnetic drum separators, which have a separation efficiency of 99.4%, but pose a safety risk due to the permanent magnetic field.

Objectives
The team aims to design a lab-scale electromagnetically enhanced hydrocyclone and test the separation efficiency in several parametric studies.

Approach
- The team visited the Robinson Run Plant in WV to analyze the current magnetite recovery process
- Safety and efficiency were found to be the most important design parameters
- Previous research suggested a multi-pole design on the cyclone cylinder
- The team used the expertise of FLD Smidth to design a Krebs hydrocyclone for use in testing
- The team used the expertise of Electro-Mec to design and build a 4-pole electromagnet
- Testing was performed to study pulsing direction, pulse frequency, and current
- Classification efficiency was determined by the percent mass of particles directed to cyclone underflow as a fraction of total particles exiting the cyclone
- Wet sieving was performed to determine the particle size distribution to each cyclone stream

Outcomes
The team made the following conclusions:
- The electromagnetically enhanced hydrocyclone offers a flexible magnetic field that can be turned off
- The maximum classification efficiency achieved during testing was 96.0%
- The team proposes the following testing parameters for future work:
  - Pulsing frequency
  - Electromagnet current
  - Pulsing mechanisms
  - Pump pressure
- Separation efficiency is expected to match that of the magnetic drum rollers with electromagnet optimization