Optimal Operating Point of a MgB$_2$ Based Magnetic Density Separation System

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Abstract

Superconducting MgB$_2$ wire is characterized to analyze its optimum operating point in terms of field and temperature in a magnet system designed for magnetic density separation (MDS). In order to determine the optimal configuration of field and temperature, both application costs (OPEX) and material costs (CAPEX) are estimated.

Benefits of implementing a MgB$_2$ wire

- Mg and B components are abundant
- Relatively high critical temperature
- Suitable for conduction-cooling
- Relatively low cost
- Material still developing and improving

With its relatively high critical temperature and low cost, MgB$_2$ is a prime candidate material to realize the MDS magnet. More information on the MDS system is presented on the poster by J.J. Kosse et al.

Cost estimation

**Ferrofluid**
- $M_s(H)$ relates to ferrofluid concentration
- From the concentration, the ferrofluid cost is estimated $€_{ff}(H)$ (OPEX)

**Magnet volume**
- Obtain current sharing temperature from critical surface
- Use proposed magnet design to obtain req. MgB$_2$ volume
- Conductor price $€_{MgB2}(H,T)$ (CAPEX)

**Cooling power**
- Determine required cooling power
- Penalty factor
- Life cycle + estimated avg. kWh price
- Cooling price $€_{cryo}(T)$ (OPEX)

Characterization of MgB$_2$ critical surface

A MgB$_2$ sample supplied by Columbus Superconductor SpA is characterized on its critical surface:
- Measurements are conducted over 4.2 to 30 K at a set of fields up to 10 T.
- Acquired temperature - field data allow evaluation of conductor volume and heat inleak.

Minimum field requirement

The minimum field required to operate the MDS system is determined by the waste stream specific parameters, such as:

- The heaviest mass density $\rho_{\text{max}}$
- Saturation magnetization of the ferrofluid $M_s$

The minimum required field $H_{\text{min}}$ that the magnet should generate in order to lift waste particles up to the heaviest fraction is:

$$H_{\text{min}} \sim \frac{(\rho_{\text{max}} - \rho_{ff})}{M_s}$$

where $\rho_{ff}$ is the density of the ferrofluid.

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