The design and analysis of a superconducting magnet system for magnetic density separation

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A superconducting magnet system has been designed, analyzed and optimized, serving as demonstrator for a Magnetic Density Separation (MDS) system. MDS, as a novel recycling technology, allow the selective magneto-hydrostatic separation of materials in a waste stream based on their different mass densities. Regarding the present MDS with permanent magnets, superconducting magnet offers higher flux densities and a more flexible design space, which allows for 5-10 times higher gradients (i.e. separating power), smoother field profiles and a ~ 5 times deeper fluid bed for material separation.
This work focuses on the design and optimization of superconducting magnet, cryogenic cooling and cryostat systems. The NbTi magnet design has been optimized by balancing magnet performance, stability and offered field quality, against materialand cooling cost. The zero boil-off liquid He-cooled and conduction cooling system operated at 4.2 K, are both designed, analyzed and compared. For the cryostat, the space from top magnet to the fluid should be kept narrow (< 5 cm) to maintain optimal field amplitude in the ferrofluid. This leads to the challenge of reconciling the mechanical constraints imposed by the planar coil geometry with the thermal insulation requirements. A straightforward pillar-type structural elements is designed but with a high heat in-leak, while a local reinforced structure on the top flange is also proposed and analyzed to achieve same space with less heat leak but with some manufacture difficulties. Here, the analysis and optimized design of the magnet are presented. Construction of the magnet system is planned to commence in the second half of 2017.
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