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POLYMER EXTRUSION FILTER DESIGN WITH HYBRID OPTIMIZATION TECHNIQUES

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ABSTRACT

The focus of this study is the application of derivative-free hybrid optimization methods to identify optimal extrusion filter parameters. We make use of a three-dimensional simulation model that describes the deposition of debris particles in the filter. Previous approaches to this problem used a derivative-free sampling algorithm to maximize different measures of performance of a one or two layer filter with respect to the porosity and pore diameter in each layer. A challenge in those studies and the motivation for this work was that the single-search optimization algorithm applied was prone to converge to a sub-optimal filter design for certain optimization parameters. Here we apply a hybrid optimization algorithm that combines two heuristic search methods, a genetic algorithm and a particle swarm optimization algorithm. Both are known to exhaustively search the design space and are less prone to stagnate to a local minimum but they do involve a significant number of calls to the simulator that describes the filter performance, which can be computationally expensive. To improve efficiency, we incorporate surrogate functions into the search phase. We present promising numerical results for a two layer extrusion filter design.

We discuss an optimization study of two-layer extrusion filter designs using a three-dimensional computational simulator and derivative-free hybrid optimization methods. The simulator models flow of a non-Newtonian fluid through a multi-layered filter with debris deposition. Previous studies used a derivative-free sampling algorithm to maximize different performance measures of one- and two-layer filters, relative to changes in porosity and pore diameter in each layer. A challenge in those studies, and the motivation for this work, is that the single-search optimization algorithm we used would converge to a sub-optimal filter design for certain starting points. In this work, we apply a hybrid optimization algorithm that combines two heuristic search methods: a genetic algorithm and a particle swarm optimization algorithm. Both are known to exhaustively search the design space and are less likely to stagnate at a local minimum. They do, however, require a significant number of calls to the simulator. This is computationally expensive, as each call may require thirty minutes of compute time. We improve the efficiency by incorporating surrogate functions (i.e. a cheaper approximation to the real objective function) into the search phase. We present numerical results for a two-layer extrusion filter design and discuss extensions to more complicated filter designs.

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Lea Jenkins is an associate professor of mathematical sciences at Clemson University. Her research interests are in porous media flows, ranging from groundwater to filtration applications.