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Effects of confinement & surface roughness in electrorheological flows AHMED HELAL, Department of Mechanical Engineering, Massachusetts Institute of Technology, MARIA J. TELLERIA, Pneubotics, JULIE WANG, Department of Mechanical Engineering, Massachusetts Institute of Technology, MARC STRAUSS, MIKE MURPHY, Boston Dynamics, GARETH MCKINLEY, A.E. HOSOI, Department of Mechanical Engineering, Massachusetts Institute of Technology — Electrorheological (ER) fluids are dielectric suspensions that exhibit a fast, reversible change in rheological properties with the application of an external electric field. Upon the application of the electric field, the material develops a field-dependent yield stress that is typically modeled using a Bingham plastic model. ER fluids are promising for designing small, cheap and rapidly actuated hydraulic devices such as rapidly-switchable valves, where fluid flowing in a microchannel can be arrested by applying an external electric field. In the lubrication limit, for a Bingham plastic fluid, the maximum pressure the channel can hold, before yielding, is a function of the field-dependent yield stress, the length of the channel and the electrode gap. In practice, the finite width of the channel and the surface roughness of the electrodes could affect the maximum yield pressure but a quantitative understanding of these effects is currently lacking. In this study, we experimentally investigate the effects of the channel aspect ratio (width/height) and the effects of electrode roughness on the performance of ER valves. Based on this quantitative analysis, we formulate new performance metrics for ER valves as well as design rules for ER valves that will help guide and optimize future designs.

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