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TOWARDS SIMULATION-AIDED DESIGN OF SINGLE-SCREW EXTRUDERS

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Abstract: In this talk we present novel concepts for the simulation-based design of single-screw extruders. While single-screw extruders are widely used because of their low operating costs, the produced melt often suffers from an inhomogeneous material distribution. This is enhanced by inadequate process design. Therefore, extensive running-in trials are carried out to enhance the extruder's design until the produced melt is sufficiently conditioned for further processing. It is our aim to develop techniques that support the currently experience-based design process by numerical design. Based on a method already used in die design, we propose concepts for the method's extension towards the numerical design of mixing-elements in single-screw extruders. We assume that we start the design process with a functional, but possibly inefficient initial design. The novelty in our method is to determine a suitable geometry that provides sufficient mixing by reformulating the mixing problem into a shape-optimization problem. Instead of solving the inverse problem, we try to circumvent problems that this may involve by applying iterative black-box optimization based on an efficient low-order parameterization of the geometry. Our setup consists of four fundamental steps: (1) definition of a suitable objective function,(2)flexible parameterization of the geometry,(3)flow simulation, and (4) geometry modification based on an optimization algorithm. We conduct non-isothermal flow simulations modeling the melt as an incompressible shear-thinning fluid. By utilizing the shear-slip mesh update method we resolve the screw's and barrel's relative motion on boundary-conforming grids. Since the success of this black-box optimization approach is largely reliant on a small number of optimization parameters, our current work is focused on new ideas to parameterize extruder screws in a flexible yet efficient way. We discuss techniques based on global NURBS representation of the geometry – as previously used in die design – and contrast those with new ideas developed for the extruder optimization. Limitations inherent in the new approach are outlined, as well as its ability to exploit parallelization in an HPC environment. This work covers two aspects: (1) We review the application of the developed optimization framework to the shape optimization of extrusion dies, and(2)we detail the extension of the framework towards the optimization of mixing elements in single-screw extruders. Special focus is put on suitable geometry parameterizations reflecting the assumed limitation on the number of optimization parameters.