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Modeling of free and moving interfaces in polymer processing

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The presentation will review approaches for free and moving boundary problems found in polymer processing operations. There has been tremendous progress in modelling problems with free and moving boundary problems. Injection mold filling has progressed such that the filling of very large complicated three-dimensional parts is routinely simulated. Profile extrusion is a type of free surface problem where 3-D steady state models capture such effects as die swell and flow imbalances within the die that will lead to product problems. Blown film extrusion is another example of free surface problem where there has been recent progress in capturing heat transfer phenomena and the effect of the air rings on the bubble shape. Examples of moving interfaces include multiple material extrusion or injection into cavities where the fluid interface is captured both in steady state and dynamic simulation. Moving boundary problems include the rotation of screw elements in single and twin-screw extruders, where the quasi-steady state assumption is made, but also dynamic moving surface models are now being developed to capture flows in these geometries. These types of problems tend to have a free or moving surface that is either a continuous surface that has a change in properties (e.g. multi-fluid flows in an extrusion die or mold filling) or a moving surface that has a position defined by geometry (e.g. a rotating screw element in an extruder). The types of mathematical approaches that have been used to capture these free and moving boundaries include front capturing and front tracking methods such as: spines, volume of fluid methods, fictitious species, and level set methods. These techniques are used in combination with finite element methods, boundary fitted finite volume and, less often, boundary element methods. Recent work has addressed the challenging problem of multi-scale, multi-surface problems such as those found in mixing problems, which include features such as multiple length scales, many surfaces, and subdomains that can form and disappear.