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Multi-Physics Simulation of Extrusion Molding Process for Viscoelastic Materials

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Polymer Materials that are widely used for the extrusion molding process have viscoelastic properties mostly. A number of studies on viscoelastic materials have been therefore carried out experimentally and theoretically on purpose to improve the quality of the polymer products, to acquire fundamental knowledge of those properties, and so on. Numerical simulation is one of the effective techniques to understand the characteristics of polymer melt flows. However, three-dimensional numerical simulation for viscoelastic polymer melt flowing through extrusion dies has been rarely conducted in detail, so that simulation needs a mount of the computational storage for calculating the time evolutions of that shear stress tensor components. In our recent study, a flow simulation code for viscoelastic materials based on the techniques of finite element analysis was developed. This FEA code can simulate the vortex in sudden contraction flow, the die-swell flow during extrusion with a free surface through a nozzle, and the encapsulation flow in multi-layer polymer coextrusion. Furthermore, a finite element analysis code, which can solve the fluid/structure interaction problems, was developed in our previous study. This code can deal with both weak and strong coupling methods and simulate the film coating process with elastic deformation of wire, the compression molding with elastic deformation of insert parts, and so on. In the present study, above-mentioned two FEA approaches were coupled and applied to the extrusion molding process for viscoelastic polymer materials. Experiments of polymer melt flowing through an actual manifold die were also carried out, and measured and calculated results were compared to verify the validity of the proposed new approach.