

Analysis of Polymer Plasticization by DEM – MPS Coupling Simulation

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ABSTRACT

In the polymer processing, twin screw extruders have been widely used for process of polymer/fiber/filler compounds, devolatilization, reaction, and so on. Material of solid polymer is fed into the extruder which consists of two screws in closed barrels. The material is melted by barrel heating and shear stress of the screw during conveying by the screw rotations, and melt polymer is continuously extruded from the front end of the extruder. One of important extruded processes by the twin screw extruder is polymer plasticization, which has not accurately been predicted due to complex physical phenomena by numerical simulation.

We have developed a DEM – MPS coupling method for simulation of polymer plasticization in the extruder. Particle behavior of solid polymer is calculated by the DEM (Discrete Element Method) [1] and the material above the melting point, i.e. melt polymer is calculated by the MPS (Moving Particle Simulation) method [2]. The solid particle motion is evaluated by Newton's equations of motion for the translational and rotational. The contact force between particles is given by a spring-dashpot-slider model in the DEM. Behavior of the fluid particles is solved by the incompressible Navier-Stokes equations which are discretized by the MPS method. Shear viscosity of melt polymer shows high values in the range from 10 Pa·s to 10⁵ Pa·s as a shear-thinning behavior. Therefore, the model of highly viscous non-Newtonian fluids was employed [3].

We calculated the process of polymer plasticization in an intermeshing co-rotating twin screw extruder by the proposed method. The simulation geometry consists of screw elements divided into the polymer conveying and melting zone. The simulation results show that the particles of solid polymer into the extruder are conveyed by rotations of two screws; then it gradually melts with increasing temperature by the mixing screws. The plasticization behavior of polymer in the simulation results is in good agreement with that of the experiment data. Therefore, the proposed DEM – MPS coupling method can be used for predicting the plasticization process of polymer in the twin screw extruders.

REFERENCES

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