ABSTRACT

Extrusion is one of the most efficient and widely practiced fabricating techniques for producing long rubber profiles such as mono-component glass run, co-extrudate, multicomponent profiles, metal-reinforced rubber profiles, and cellular rubber profiles. Die swell is the most common phenomenon while extruding the rubber profiles. The dimension and the shape of the extrudate change owing to die swell, leading to complexity while designing the die for rubber products. In view of the extensive applications of rubber extrudate products, i.e., automotive profiles, doors, windows, medical tubings, and many critical tire components, we have studied the swelling behaviour of rubber compounds during extrusion using CFD. In the present study, filled-EPDM rubber compounds were chosen due to their widespread applications in automotive seals/weather-strips. The thermal and rheological properties of the compounds are characterized by ODR, MCR, Capillary rheometer, DSC, and guarded hot plate. The experimental data obtained from MCR and Smartrheo at low and high shear rates are merged to perform the curve fitting using the shear rate-dependent viscosity models. It was found that the "Carreau-Yasuda law" exhibited an excellent fit for a wide range of shear rates with the experimental data. Furthermore, the curve fitting is performed using the temperature-dependent viscosity model, as viscosity is the function of both shear rate and temperature. "Arrhenius approximate law" showed an excellent fit for a wide range of shear rates with the experimental data. The model-specific parameters are evaluated from the curve fitting to perform the simulation. The 3D models for mono extrusion, co-extrusion, and multi manifold extrusion were prepared to perform the simulation and to predict the extrudate shape and dimension. Then, the results derived from simulations were compared with the actual complex-shaped automotive profiles. Moreover, the required die shape has also been computed using the inverse extrusion simulation for a particular profile shape. Finally, the simulated result is compared with a real profile, and an efficacy of more than 98% has been achieved. Overall, the simulation technique has the potential to find its application as a proficient die designing tool which reduces the "trial-and-error" in extrusion industries.

Keywords: Extrusion; Co-extrusion; Multimanifold extrusion; Filled EPDM compound; Finite element analysis; Automotive rubber profile