PROFILE EXTRUSION DIE DESIGN: THE EFFECT OF WALL SLIP

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Abstract

In the past, the design of extrusion dies was usually based on trial-and-error procedures, which strongly depended on the designer knowledge and experience and often required a large number of iterations. During the last decades, the progressive development of computational fluid dynamics and of computer technology (enabling the implementation of more realistic complex rheological models together with more accurate discretization and interpolation schemes) allowed the replacement of the empirical trial-and-error process by a computational systematic method, leading to significant savings in time and human and material resources. More recently, this research team successfully implemented and validated an optimisation methodology [1], encompassing the numerical solution of flow and heat transfer equations by a finite-volume based three-dimensional code, aimed at balancing automatically the flow in complex profile extrusion dies. In this numerical method, the no-slip boundary condition at the die channel walls was assumed initially. In fact, the majority of studies concerning the flow in extruder screws, extrusion dies and rheometers normally proceed from the assumption that the flowing melt adheres to the wall. However, there are certain plastic melts such as poly(vinyl chloride) (PVC), high-density polyethylene (HDPE) and elastomers, often used in the production of plastic profiles, that show wall-slipping under certain conditions. Wall slip by polymer melts has been studied by several authors [2-4], resulting in a comprehensive description and development of phenomenological models to handle the problem. Since wall slip within the die affects the overall velocity field and post-extrusion behaviour, it was decided to implement the wall-slip boundary condition in the above referred numerical code. This work described this implementation, discusses specific numerical issues related to the wall-slip boundary condition upon the flow and stress fields and compares results of simulations obtained in a particular extrusion die with and without consideration for wall slip.

References