Plastic Flow with polyXtrue software

success stories

Computational Validation of the Experimental Observations for a Profile Die

Fig. 1 Geometry of the two profile dies for glass-run seal for window of a car, (a) plate die, (b) front view of stepped die, (c) rear view of stepped die

(a) (b) (c)

Challenge

While developing a profile extrusion die for one of their major customers, Exxon Mobil wanted to validate their die development process by computer simulation of the flow in two different profile dies for extrusion of a glass-run seal for window of a car. Geometries of the two profile dies, shown in Fig. 1, were quite complex. In particular, thickness of the tabs at the ends of the U-shaped profile is much smaller than the main body of the profile. Furthermore, thickness of the right leg is significantly larger than the thickness of the left leg, and is also larger than that of the bottom of the U-shaped profile. Therefore, velocity distribution at the die exit is expected to be much higher in the thicker portions if a simple plate die is used for extruding the glass run seal. In order to balance the flow at the exit, in the stepped die shown in Fig. 1 (b, c), a feeder plate is used. The feeder plate has a larger opening in the thinner portions of the exit profile and a smaller opening in the portions with thicker exit profile. Since the geometry of the extruded profile for the glass-run seal is quite complex, the challenge was to set-up the finite element formulation of the flow in the profile die and simulate the flow accurately within a reasonable computation time on a PC.

Solution

In order to validate their experimental findings for the two profile dies, Exxon Mobil contacted Plastic Flow to simulate the flow through the two profile dies. Since Exxon Mobil already had a commercially available finite element mesh generation software, Exxon Mobil generated the finite element mesh in the two dies and provided the mesh information to Plastic Flow. At Plastic Flow, the finite element mesh generated by Exxon Mobil was imported into the polyXtrue software. Next, the boundary conditions provided by Exxon Mobil, including flow rate, die wall temperature, and polymer temperature at die entrance were specified in the polyXtrue software.

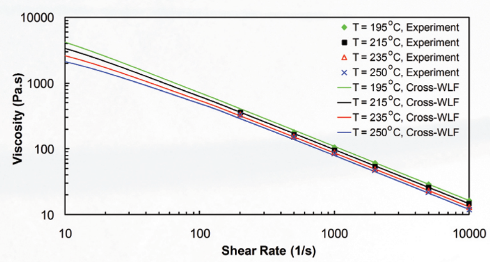


Fig. 2 Viscosity of Santoperene

Exxon Mobil also provided Plastic Flow the viscosity and thermal properties (thermal conductivity, density and heat capacity) of the polymer used (TPE, Santoperene™). The viscosity data provided by Exxon Mobil was used by Plastic Flow to fit the Cross-WLF viscosity model to the data shown in Fig. 2.

After setting up the flow problem with proper processing conditions and material properties, the flow in the two profile dies was simulated using the polyXtrue software. For the finite element meshes for the plate and stepped dies provided by Exxon Mobil, which had 504,514 and 467,374 tetrahedral finite elements, respectively, each of the flow simulations was completed in less than half an hour on a PC. Plastic Flow provided the velocity, pressure and temperature distributions predicted by polyXtrue software to Exxon Mobil for verification of their experimental observations.

Results

•The predictions from polyXtrue accurately matched the experimental observations of Exxon Mobil.

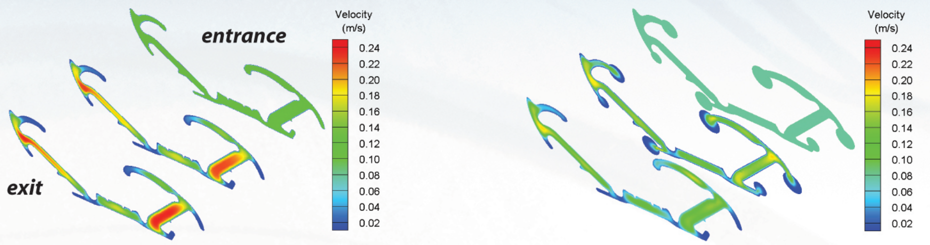
•The stepped die shown in Fig. 1 (b, c) was found to provide a much more uniform velocity distribution at the die exit than the velocity distribution in the plate die shown in Fig. 1 (a).

•The stepped die (Fig. 1 b, c) is currently being used to extrude the glass-run seal for window of a car.

"...each of the flow simulations was completed **in less than half an hour** on a PC."

Velocity Distributions

Fig. 3 shows the velocity distributions in three different cross-sections of the two profile dies predicted by the polyXtrue software. In the plate die in Fig. 3 (a), because of the wider die opening, the velocity at the exit is much larger in the right leg and in the T-joint region of the left leg. Since the opening in the right leg of the feeder plate is smaller, the exit velocity in the right leg of the stepped die in Fig. 3 (b) is significantly reduced in comparison to that in the plate die. In general, the velocity distribution at the exit of the stepped die in (Fig, 3 b) is much more uniform than that at the exit of the plate die (Fig. 3 a).

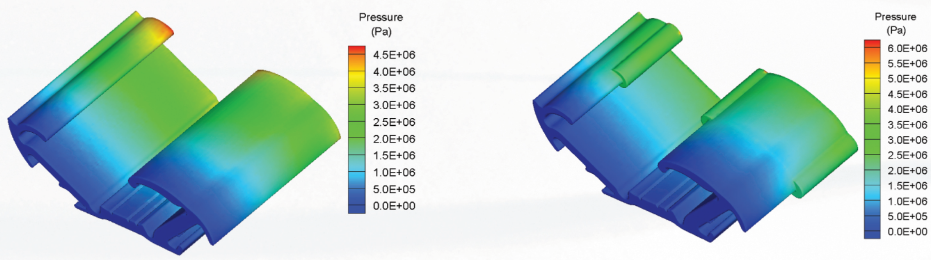


(a) *(b)*

Fig. 3 Velocity distribution in (a) plate die, (b) stepped die

Pressure Distributions

The predicted pressure distributions in the two profile dies are shown in Fig. 4. The sudden drop in the pressure near the entrance of the two dies is because of the constant velocity specified at the entrance of the dies. As the flow develops quickly from the uniform velocity distribution specified at the die entrance to a fully developed velocity distribution, it results in the sharp pressure drop near the die entrance. If this sharp pressure drop near the die entrance is ignored, the total pressure drop in both the dies is about 3.5 Mpa.

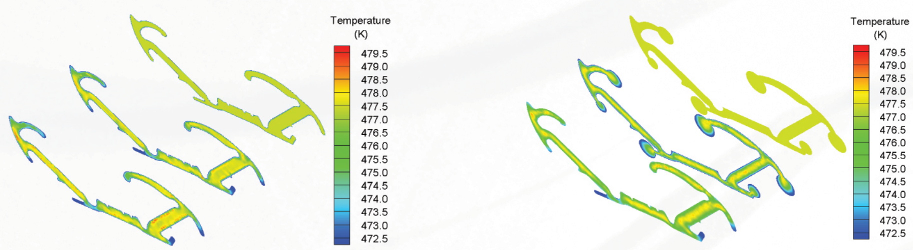


(a) *(b)*

Fig. 4 Pressure distribution in (a) plate die, (b) stepped die

Temperature Distributions

For the two dies, Fig. 5 shows the predicted temperature distribution in the three different cross-sectional planes. The temperature distributions in the two dies are quite similar. Starting at 477.4 K (203.4 ℃), due to viscous dissipations, in both dies the temperature increases to about 480 K (207 ^{o}C) at certain locations at the die exit



(a) *(b)*

Fig. 5 Temperature distribution in (a) plate die, (b) stepped die

Experimental Extruded Profiles

Fig. 6 shows the extrudate profile obtained from the two different dies. It is noted that for the profile extruded by using the plate die both the legs of the U-shaped cross-section are smaller than those in the profile obtained using the stepped die.

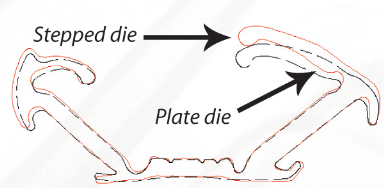


Fig. 6. Shape of the extrudate profile. Plate die: black line. Stepped die: red line