Development of Die Geometry for a Profile Die

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Material Properties of the Polymer

Viscosity model

The experimental data provided by *ABCD Company* was used to fit the Cross-WLF model for shear viscosity.

Cross-model for shear viscosity (η):

$$\eta = \frac{\eta_0}{1 + (\eta_0 \dot{\gamma} / \tau^*)^{1-n}}$$

where $\dot{\gamma}$ is the shear rate, and the WLF model for temperature dependence of zero-shear viscosity (η_o) is given below:

$$\eta_o = D_1 \exp\left[-\frac{A_1 (T - T_a)}{A_2 + (T - T_a)} \right]$$

The values of Cross-WLF model parameters for the polymer obtained by fitting the model to the experimental data are:

$$D_1 = 2.134 \times 10^{12} \text{ Pa.s}$$
$$A_1 = 25.61$$
$$A_2 = 170.73 \text{ K}$$
$$T_a = 183.0 \text{ K}$$
$$\tau^* = 3.17 \times 10^5 \text{ Pa}$$
$$n = 0.1$$

Experimental data and the fit obtained by using these cross-WLF viscosity model parameters are shown in Fig. 1.

Thermal Properties

Thermal conductivity:	1.332 W/mK
Heat capacity:	1.0 kJ/kg K
Density:	3030.0 kg/m^3.

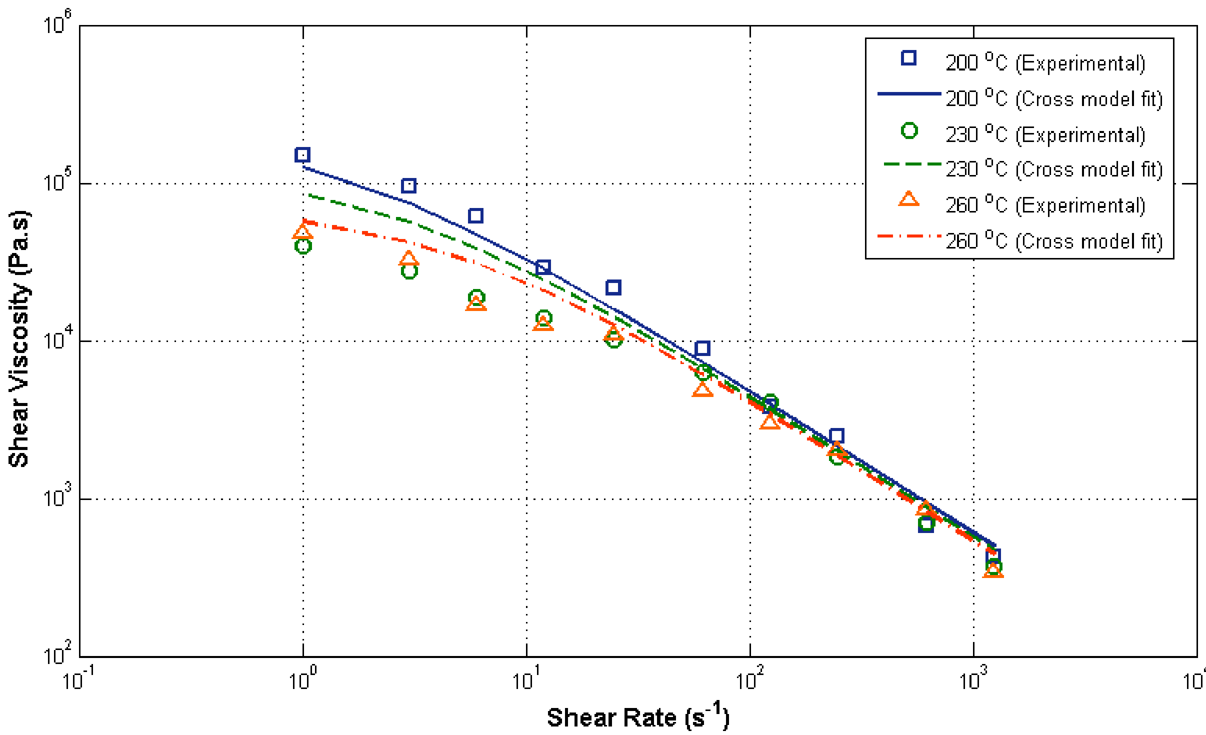

Fig. 1 Viscosity of the polymer.

Processing Conditions

Flow rate corresponding to 6000 lb/hour of throughput was enforced at the die entrance. Die wall temperature and polymer temperature at the die entrance was specified to be 400 ^{o}F (478 K).

Die Geometry

Finite element mesh in the final die geometry developed for a balanced flow at the die exit is shown in Fig. 2. This mesh was employed for simulating the flow using the PELDOM software. The finite element mesh has 710,239 tetrahedral finite elements.

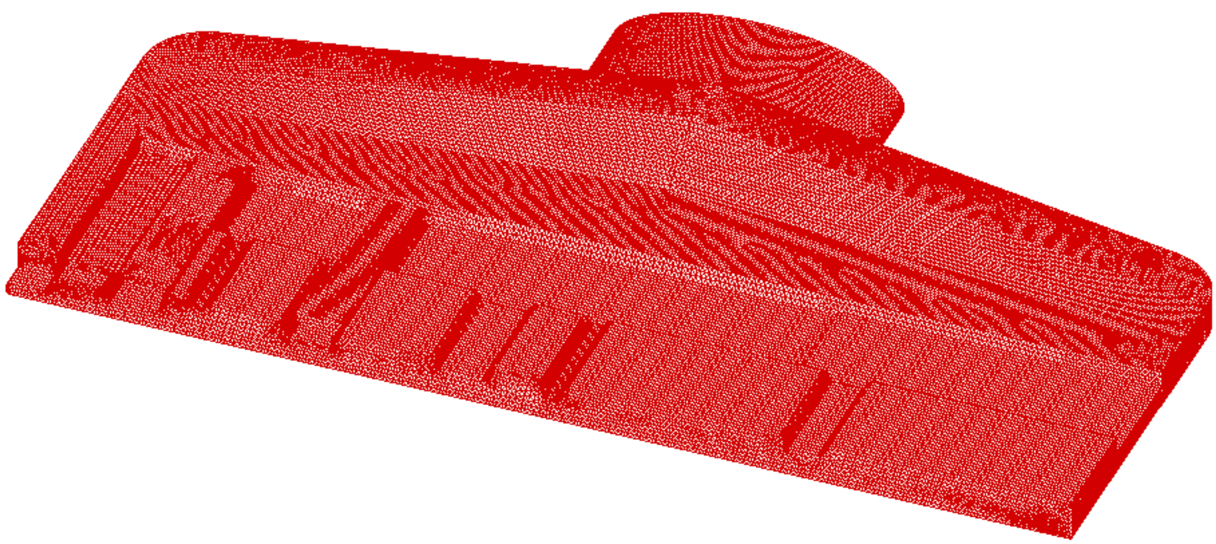

Fig. 2 Finite element mesh used for flow simulation.

Flow Simulation Results

For the die channel geometry in Fig. 2, the velocity, pressure, and temperature distributions predicted by the PELDOM software are shown next.

Velocity Distribution

The flow channel geometry was developed to obtain a uniform velocity distribution at the die exit. For the die channel geometry in Fig. 2, velocity distributions in five cross-section planes are shown in Fig. 3. Uniformity of velocity distribution at the die exit is evident from Fig. 3.

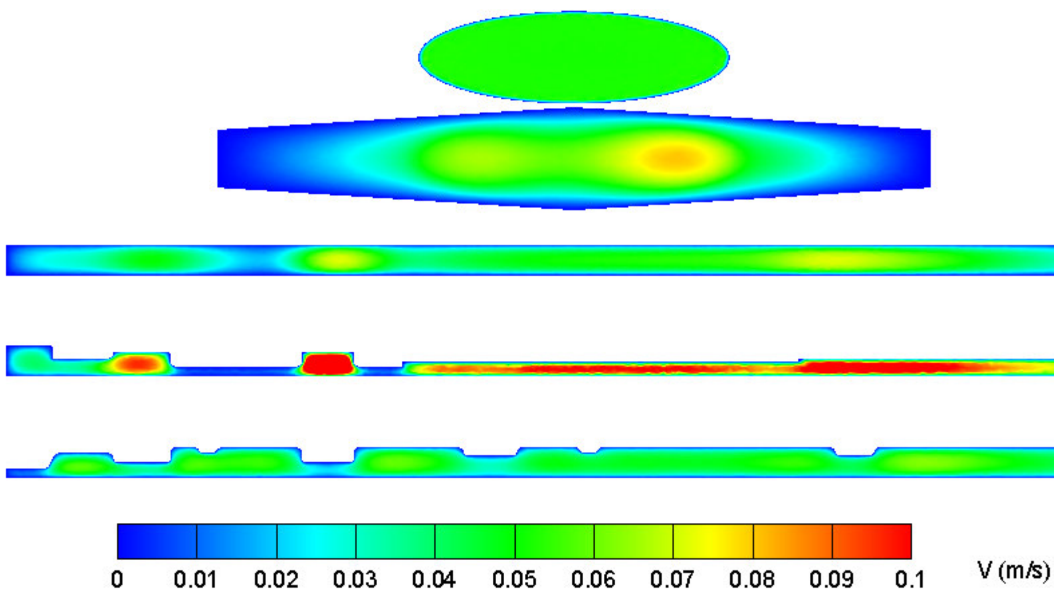

Fig. 3 Velocity distribution in the profile die.

Pressure Distribution

For the die channel geometry in Fig. 2, the pressure distribution predicted by the PELDOM software is shown in Fig. 4. As expected, the pressure is zero at the exit and maximum at the die entrance.

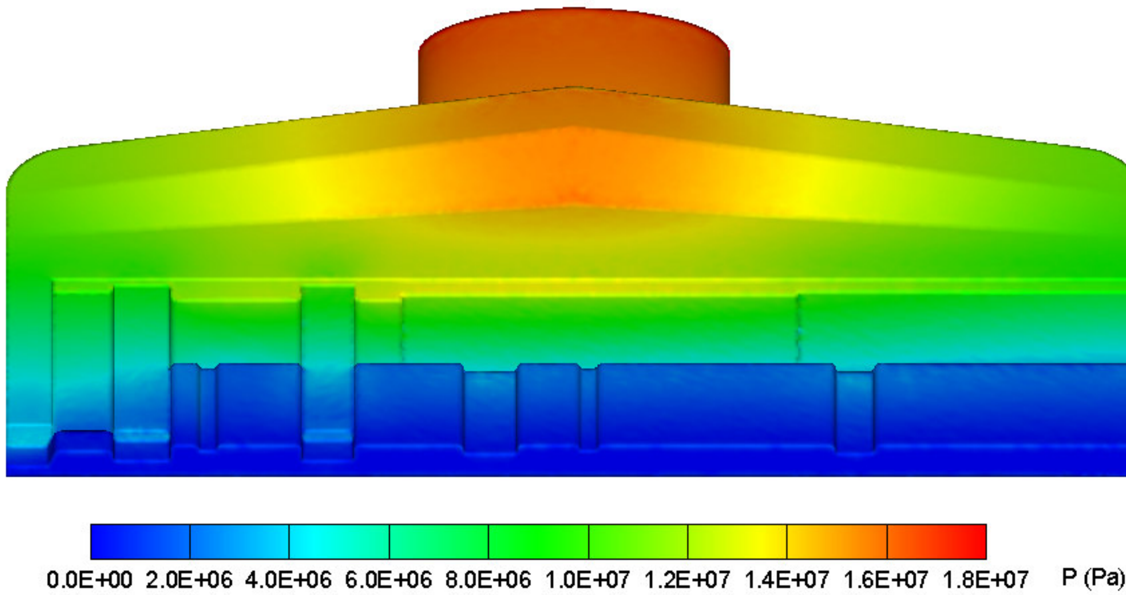

Fig. 4 Pressure distribution in the profile die.

Temperature Distribution

Starting with temperature of 478 K (400 ^oF) at the entrance, the temperature at certain locations near the die walls increases due to shear heating. However, the increase in temperature is generally quite small, and is not expected to affect the extrudate profile significantly.

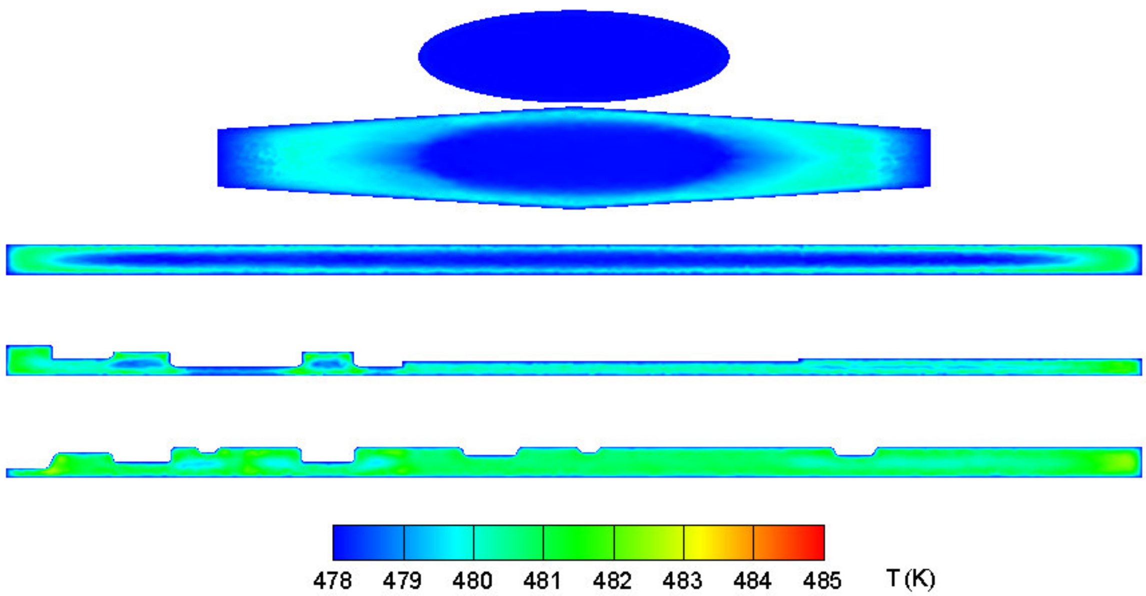

Fig. 5 Temperature distribution in the profile die.

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