Plastic Flow with polyXtrue software

success stories

Development of a Profile Die for Extrusion of a HDPE Part

Fig. 1 Shape of the extruded profile

Challenge

In order to prevent one of its equipment from tipping over during operation, a United States based manufacturing company wanted to attach an additional weight at the back of the equipment. The part which would add the extra weight to the equipment was to be manufactured by extruding a highly filled HDPE. In order to fit with the other components of the equipment, the part used to add the extra weight to the equipment had a large number of step changes in the thickness (Fig. 1), making the profiled part very difficult to extrude. The manufacturing company already had an extrusion die with the opening at the exit being the same as the required profile, but the previously designed die had many problems. In particular, almost all the polymer was coming out from the thicker portions near the middle of the profile, and no polymer was coming out through the thinner portions of the die near one side of the exit profile. The challenge was to redesign the die channel geometry such that the polymer will be extruded uniformly through thicker as well as thinner portions of the die.

Solution

The manufacturing company contacted Plastic Flow to redesign the profile die for extruding the HDPE part. The die channel geometry was to be developed such that the polymer is extruded uniformly through the complete cross-section of the complex-profile.

In order to distribute the polymer across the complete width of the complex profile, Plastic Flow changed the circular entrance in the existing die design to an elliptical entrance. Next, as shown in Fig. 2, a coat-hanger type manifold was used to further improve the uniformity of the flow from the die entrance near the middle towards the two sides of the profile cross-section. However, a uniform distribution of the polymeric flow across the complete width of the profile cross-section was not sufficient to achieve a uniform flow at the die exit. If the flow is uniformly distributed at the entrance of the die land (as shown in Fig. 2 die land is the final portion of the die near the exit which has the same cross-section as the required extrudate profile), more polymer will be extruded from the thicker portions of the profile and less polymer through the thinner portions of the exit profile. In order to obtain a uniform velocity through the thicker as well as thinner portions of the profile, in the die shown in Fig. 2 an additional feeder plate with varying cross-section was incorporated between the coat hanger die manifold and the die land. The initial geometry of the opening in the feeder plate was obtained with the basic concept that the feeder plate should have a larger opening in the thinner portions of the exit profile and smaller opening in the portions with thicker exit profile. Starting with an initial estimate for the shape of the opening in the feeder plate, polyXtrue software was employed to iteratively improve the feeder plate geometry such that a uniform velocity distribution was obtained at the die exit. In each design cycle, polyXtrue was used to simulate the flow. Based upon the velocity distribution at the die exit predicted by polyXtrue, the geometry of the feeder plate was modified and the cycle was repeated. Ten design cycles with flow simulation using polyXtrue software were required to obtain the final geometry of the profile die shown in Fig. 2. It should be noted that just the use of the feeder plate was not sufficient to balance the flow in the profile die. To increase the flow in some of the narrow portions of the exit profile, the thicker cross-section of the feeder plate was extended into the initial portion of the die land.

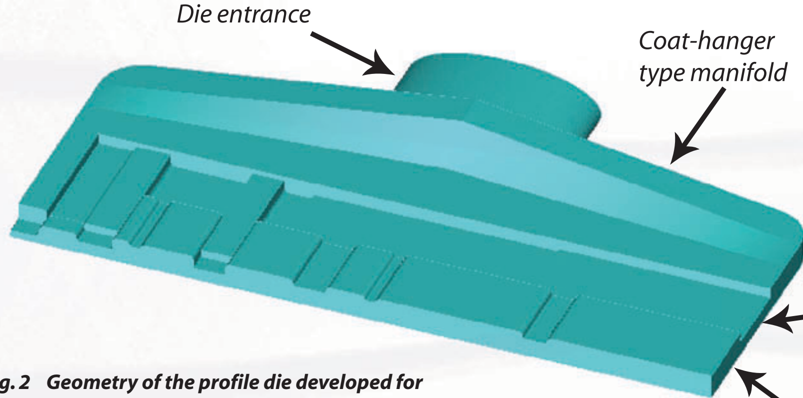

Fig. 2 Geometry of the profile die developed for extrusion of the HDPE part

Results

•The complete design of the profile die with ten design cycles using the polyXtrue software was completed within one week.

•The die is currently being used for extruding the complex profile for the HDPE part without any change in the die geometry developed by Plastic Flow.

"...polyXtrue software was employed to iteratively improve the feeder plate geometry such that a uniform velocity distribution was obtained at the die exit."

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Velocity Distribution

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.

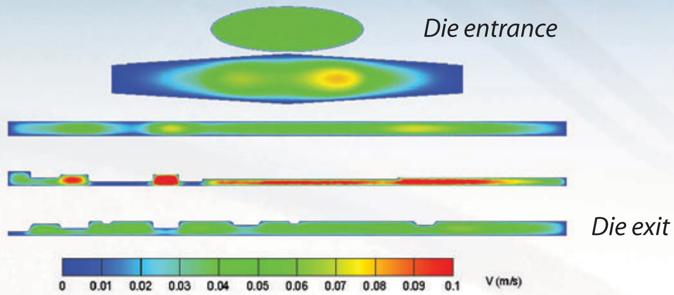

Fig. 3 Velocity distribution in the profile die

Pressure Distribution

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

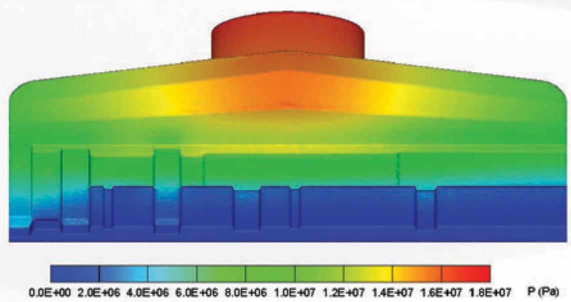

Fig. 4 Pressure distribution in the profile die

Temperature Distribution

Starting with temperature of 478 K (400 ^{o}F) at the entrance, which is the same as the die wall temperature, the temperature of the polymer inside the die increased due to shear heating. However, the increase in temperature is generally quite small, and was not found to affect the extrudate profile significantly.

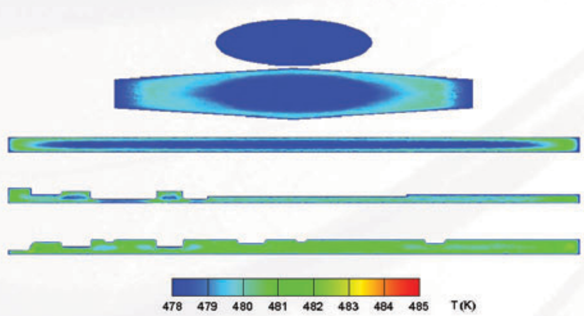

Fig. 5 Temperature distribution in the profile die