COOLING THE FORMED PART

So far, we have heated the sheet and stretched it. The sheet is now against the cooler mold surface. This part considers how the sheet cools.

Sheet Characteristics on the Mold

As discussed earlier, the sheet stretches differentially against the mold surface. That is, the sheet that touches the mold first yields the thickest portion of the formed part. The sheet that touches the mold last is usually the thinnest portion of the formed part. Further, the sheet that touches the mold first is cooled longer than the sheet that touches the mold last. The difference in thickness, cooling rate, and cooling time across the part surface may lead to different thermal stresses in the final part. And these different thermal stresses, together with the different degrees of stretching in the part during forming, can lead to part problems such as warping, uneven shrinkage, and part distortion. These problems are not restricted to general part size or initial sheet thickness or nature of the polymer, but can occur in thin-gauge and heavy-gauge parts.

Energy From the Sheet to the Air

For all but matched die forming, the free part surface, or the part surface away from the mold surface, is exposed to ambient mold conditions. For thin-gauge parts that are pressure formed, the free surface environment is static or quiescent air. Air has notoriously poor heat removal characteristics, so the free surface cools primarily by conduction through the side of the sheet that is in contact with the mold surface. For heavy-gauge parts, fans are usually used to remove heat from the free surface. The more rapidly the free surface, the more rapidly the part will cool. In certain applications, humidified air or air containing water microdroplets is used to further enhance the rate of cooling from the free surface. The technical reason for trying to quickly cool the free surface is that, if both sides of the sheet are cooled equally, the sheet cools four times faster than if only one side is cooled.

Keywords: coolant channel, active cooling, conduction, convection, free surface

THERMOFORMING 101

[This is one in a series of articles introducing general concepts in thermoforming.]