

Trials Reveal Impact of Plug Design on Part Quality

It is one of our favorite thermoforming questions: "Which is more important - the plug material or the plug geometry?" It's really a trick question, though, because the answer is usually, "It depends!" CMT Materials was recently approached by a customer with a stubborn plug mark on a cup. Together, we performed a test with 2 types of HYTAC[®] plug assist where multiple variables were involved.

The cups in question had a plug mark at 20mm from the bottom of the cup. After experimenting with the plug geometry and the plug material, there was a noticeable improvement in the appearance of the cup. It was not clear, however, if the improvement was a result of the different type of plug material or because of the different shape of the plug. In order to get a better understanding, we ran a controlled trial.

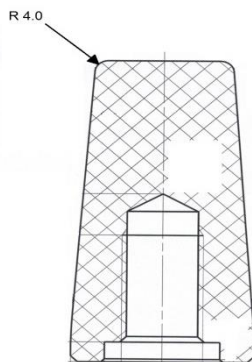
General details

- Machine: tilt-mold, cut-in-place
- Part: $\varnothing 70,5\text{mm}$ (2.77")
- Material: White PP 1,05mm (0.041")
- Machine oven temperature: 408°C / (766°F) (top and bottom)
- Sheet temperature: $\pm 150^\circ\text{C}$ (302°F)

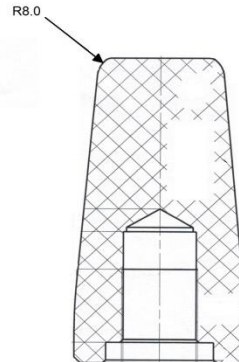
The test was run with 4 different types of plugs in the same row of the tool.

1. HYTAC XTL: Small Radius (R 4.0) Angle 4.0° (Cavity 5)
2. HYTAC FLX: Small Radius (R 4.0) Angle 4.0° (Cavity 3)
3. HYTAC XTL: Large Radius (R 8.0) Angle 5.0° (Cavity 2)
4. HYTAC FLX: Large Radius (R 8.0) Angle 5.0° (Cavity 4)

The machine was cycled for approximately 3 minutes with cups measured from the same shot.



Plug radius R4.0



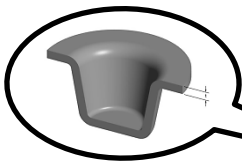
Plug radius R8.0

1. HYTAC XTL: Small Radius (R 4.0) Angle 4.0° (*Cavity 5*)
There is a plug mark at 20mm from the bottom of the cup.
Enough material in the bottom; bottom thickness is good.
2. HYTAC FLX: Small Radius (R 4.0) Angle 4.0° (*Cavity 3*)
There is a plug mark at 20mm from the bottom of the cup.
Less material in the bottom; bottom thickness is acceptable.
3. HYTAC XTL: Large Radius (R 8.0) Angle 5.0° (*Cavity 2*)
There is no line at the bottom of the product.
Enough material in the bottom; bottom thickness is good.
4. HYTAC FLX: Large Radius (R 8.0) Angle 5.0° (*Cavity 4*)
There is no line at the bottom of the product.
Less material in the bottom; bottom thickness is acceptable.

Conclusion & Discussion

The plug with the small radius (R 4.0) created a plug mark at 20mm from the bottom of the product. HYTAC XTL carried more material to the bottom compared to HYTAC FLX. **Plug No. 3, HYTAC XTL with Radius = R 8.0, gave the best result in this test.**

What the test revealed is that small changes can have a large impact on the quality of the final part. With increasing demands from global brand owners, converters must be able to meet quality standards from the first part to the last. These trials revealed that a deeper understanding of how plastic interacts with the both the plug material and the plug geometry can be the difference between a successful part and a rejected part.



#1: IMPROVE MATERIAL DISTRIBUTION

No one likes thin spots; everyone likes consistent and evenly distributed walls. Using the right plug material, geometry and processing techniques will ensure uniform wall thickness and a quality part.

