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Minimize Warpage of Smart Device Pad Cover with Optimized Gate Layout

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Kalix® high-performance polyamides (HPPA) are ideally suited for structural components used in smart devices. They deliver high stiffness and impact strength, excellent dimensional stability, and a high-quality surface finish even with very high glass loadings. These attributes combined with a high flow rate, fast cycle times, and low tendency to flash make Kalix® HPPA resins a cost-effective choice for injection molding high volumes of thin-walled, structural components for smart devices.

As with all molded electronic components, minimal warpage is essential. Solvay conducted a study using a variety of gate layouts with the purpose of minimizing the warpage of a telecom pad cover in order to develop the recommendations presented in this document.

Kalix® 9950, a 50 % glass-filled grade, was the HPPA compound used in this study. Because of the high glass fiber content, the distribution and orientation of the fibers must be carefully controlled. This can be achieved by optimizing the layout of the gates through which molten resin flows to fill the part.

Design Part Dimensions

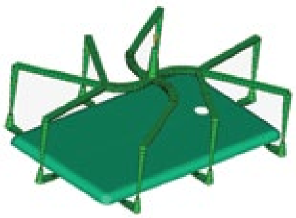
For this study, we selected a typical pad cover with the following dimensions:

- 178-mm diagonal
- 162 x 100 x 6.8 mm (l x w x h)
- 0.8-mm thickness

Gate Layout Configurations

Thin-walled parts generally have multiple gates in order to balance flow and reduce warpage. Because gate layout can have a greater impact on warpage than processing conditions, a Design of Experiment (DOE) was made to optimize gate locations using the same processing conditions, including melt and mold temperatures as well as and injection and packing profiles. A variety of gate layout configurations were injection molded based on an 8-gate layout where the gates are symmetrically positioned around all four edges (Figure 1).

Figure 1: Configuration using 8 gates

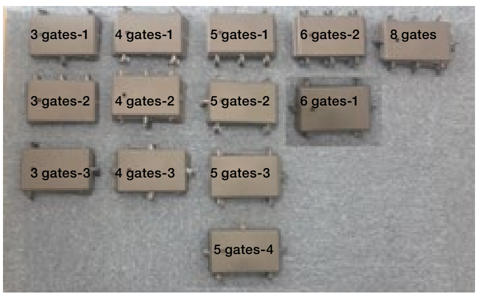


The labeling system used in the optimization study consists of the number of gates used in a design followed by the various layout options molded for that number of gates. For example, the 3 gate design was molded using 3 different gate layouts; therefore, the molded parts are referenced as 3 gates-1, 3 gates-2 and 3 gates-3.

The various gate and layout configurations shown in Figure 2 and summarized below:

- 3 gates, 3 layout options
- 4 gates, 3 layout options
- 5 gates, 4 layout options
- 6 gates, 2 layout options
- 8 gates, 1 layout option

Figure 2: Various gate and layout configurations



Measurements

The flatness of the top surface and the straightness of both long edges were used to determine optimal gate locations (Figure 3). Measurements for each gate option are summarized in Table 1.

All measurements were taken by Luc Dewez of Brussels, Belgium using a Nkon NEXIV system. This is a non-contact, fully-integrated system with XYZ video measurement capabilities using laser auto-focusing on the Z-axis.

Figure 3: Measurements used to determine optimal gate layout

Laser spots measured surface | Long edges measured straightness

Table 1: Flatness and straightness measurements

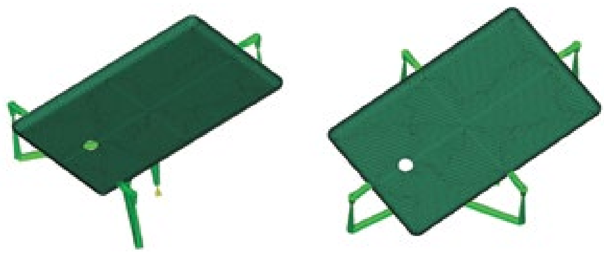
Gate Layout	Flatness [mm]	Straightness, Edge A [mm]	Straightness, Edge B [mm]
3 gates-1	0.48	0.09	0.08
3 gates-2	1.69	0.13	0.10
3 gates-3	0.36	0.15	0.13
4 gates-1	1.93	0.26	0.21
4 gates-2	0.69	0.07	0.09
4 gates-3	0.39	0.09	0.09
5 gates-1	1.10	0.21	0.18
5 gates-2	2.41	0.31	0.26
5 gates-3	2.24	0.28	0.26
5 gates-4	1.34	0.28	0.13
6 gates-1	2.12	0.30	0.29
6 gates-2	0.58	0.09	0.09
8 gates-1	2.02	0.20	0.22

Analysis

Performance specifications were set at ±0.5 mm for surface flatness and ± 0.1 mm for edge straightness. Only two gate layouts were within these specifications: 3 gates-1 and 4 gates-3.

If only flatness measurements are considered, 3 gates-3 has the minimum value of ± 0.36 mm and 5 gates-2 has the maximum value of ± 2.41 mm. Because the maximum value is 6.7 times greater than the minimum value, it can be deduced that gate layout significantly affects warpage.

Figure 4: Examples of gate layout configurations used in study



3 gates-3 | 4 gates-3

Conclusion

Because gate layout can have a significant impact on warpage, it is important to determine the optimal gate layout for a specific geometry.

For the pad cover design used in the optimization study, 4 gates-3 gave the best results for flatness and edge straightness. Based on results for all 5-gate and 8-gate layouts, adding gate locations did not improve flatness.

These conclusions may not apply to parts with more complex geometries or shapes that have significantly different configurations within the part.

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